Smallholder farming systems, adaptive capacity, and climate change in Uganda: insights for adaptation planning

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The candidate confirms that the work submitted is her own, except where work which has formed part of jointly-authored publications has been included. The contribution of the candidate and the other authors to this work has been explicitly indicated below. The candidate confirms that appropriate credit has been given within the thesis where reference has been made to the work of others.

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In writing the above paper, I designed the research questions, the methodology, and analysed the data. I wrote the manuscripts and all co-authors contributed to the revisions and editing.

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In writing the above paper, I contributed empirical data from my own PhD research, where I developed the research questions, the methodology, and analysed the data. I wrote the section of the paper relevant to the empirical findings from the Uganda case study and co-authored the remainder the paper (including revisions and edits).

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Abstract

Scientific progress and developments in technology have improved our understanding of climate change and its potential impacts on smallholder farming systems in sub-Saharan Africa (SSA). However, the persistence of such smallholder farming systems, despite multiple exposures to climate hazards, demonstrates a capacity to respond or adapt, i.e. adaptive capacity. There is potential to gain useful insights from how smallholder farmers have mobilised their adaptive capacity to identify how they may adapt to future climate hazards. However, empirical studies that explore and link past and present experiences with future climate projections are lacking. Using smallholder farming systems in Uganda as a case study, this thesis addresses this gap.

The thesis develops and applies a framework for understanding farming system adaptive capacity (FSAC) across different points in time. It uses a mixed-method, multi-level approach, combining a historical analysis of farming systems and adaptive capacity (1960-2012) with agricultural adaptations to 2030s' rainfall projections. It integrates quantitative and qualitative data from household surveys, focus group discussions, and semi-structured interviews, using a systems approach. Bringing such elements together offers an opportunity to advance understanding of smallholder farming systems and adaptation in the context of climate changes.

Findings provide insight into the dynamic nature of adaptive capacity and also enable the identification of factors that enable or constrain adaptive capacity at different levels. Over time, households that are able to maintain flexibility and diversity at the farm level are better able to respond to climate hazards. Current agricultural policy in Uganda supports specialization and intensification as market-oriented strategies, which can erode flexibility and diversity at both the farming system and individual farm level. This potentially undermines the ability of smallholder farming systems to adapt to future climate changes.

Applying and advancing the FSAC framework demonstrates that a range of actors at different levels are found to make decisions that involve a number of trade-offs between components of adaptive capacity. Policies' narrow focus on increasing productivity inadequately considers the multi-functionality of smallholder farming systems, and can undermine local-level institutions. Policies can also reduce the diversity and flexibility of smallholder farming, thus undermining adaptive capacity. Supporting a range of adaptation options provides one way to address this.

This thesis suggests that there are overlaps between policy-driven and autonomous adaptations, and thus supports calls for critical reflection on the defining characteristics of autonomous adaptation. Adaptation planning also needs to be integrated into national level and sector policy making, and policies should help to support diversity and flexibility as well as productivity and foster inclusive institutions at the local level to reduce risks of fragmentation, conflict and inefficient policy and increase the risk of policy-driven maladaptations. Finally, this thesis supports calls for a critical rethink of the suitability of agricultural modernisation policies to support smallholder farming in the context of climate change and variability.

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List of Abbreviations

ACCRA	Africa Climate Change Resilience Alliance
AEZ	Agro-Ecological Zone
APZ	Agricultural Production Zone
ASDSIP	Agriculture Sector Development Strategy and Investment Plan
CAADP	Comprehensive Africa Agriculture Development Programme
CNDFP	Comprehensive National Development Framework Policy
DfID	Department for International Development
ENSO	El Niño Southern Oscillation
FAO	Food and Agriculture Organisation
FGDs	Focus Group Discussions
FSAC	Farming System Adaptive Capacity
FSR	Farming Systems Research
GCM	General Circulation Model
GDP	Gross Domestic Product
HHS	Household Survey
IPCC	Intergovernmental Panel on Climate Change
ITCZ	Inter Tropical Convergence Zone
JFS	Jinja Farming System
MAAIF	Ministry of Agriculture, Animal Industry and Fisheries
MAM	March, April, May
MoFPED	Ministry of Finance, Planning and Economic Development
NAP	National Agricultural Policy
NAPA	National Adaptation Programmes of Action
NDP	National Development Plan
NEMA	National Environmental Management Authority
NEPAD	New Partnership for Africa's Development
NGO	Non-Governmental Organisation
PEAP	Plan Eradication Action Plan
PRECIS	Providing REgional Climates for Impacts Studies
RoU	Republic of Uganda
SES	Social-ecological system
SFS	Soroti Farming System
SIP	Sector Investment Plan
SSA	Sub-Saharan Africa
SSI	Semi-structured Interview
SLF	Sustainable Livelihoods Framework
SON	September, October, November
SRES	Special Report Emissions Scenario
UBOS	Uganda Bureau of Statistics
UNCST	Uganda National Council of Science and Technology
UNFCCC	United Nations Framework Convention on Climate Change
USAID	United States Agency for International Development

Chapter 1 Introduction

1.1 Introduction to Chapter 1

This thesis provides an in-depth case study of smallholder farming systems in eastern Uganda. It integrates a historical analysis of farming systems and adaptive capacity (1960-2012) with a forward looking analysis of agricultural adaptations to 2030s climate projections. Bringing such elements together offers a novel contribution to advance understanding of smallholder farming systems and adaptation in the face of future climate changes, including climate variability. Such insights could usefully inform adaptation planning. This chapter situates the thesis in broader climate change, adaptation and farming systems debates, before introducing the importance of smallholder farming systems and Uganda as a case study country.

1.2 Research problem and justification

Scientific progress and developments in technology have improved our understanding of climate change and its potential impacts. The most recent reports from the Intergovernmental Panel on Climate Change (IPCC) state that it is ‘likely’ (66% probability)[1] that global warming, indicated by a rise in global surface temperature, is already influencing many physical, biological and human systems (IPCC, 2014a, IPCC, 2007). In terms of biophysical impacts, climate change will affect weather patterns, leading to changes in average temperatures, increased climate variability and increased frequency and intensity of extreme weather events. These impacts will have implications ranging from the global to local level (IPCC, 2007). Establishing the impacts of these changes includes a range of uncertainties (Challinor, 2011), though it is thought that impacts will be global and wide ranging (Challinor et al., 2009).

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[1] see IPCC 2007 for a definition of the likelihood terminology.

Under projected climate changes there will be winners and losers (Leichenko and O'Brien, 2006), leaving some geographical regions and marginalised groups particularly vulnerable to the impacts (Nelson et al., 2009). Sub-Saharan Africa (SSA) has been identified as particularly vulnerable to climatic change and variability (IPCC, 2014b)., herein also referred to as 'climate changes'. Additionally, current and future sustainable socio-economic development of SSA will heavily depend on its ability to cope with current climate variability as well as the ability to adapt to future climate changes (Ogallo, 2010). Whilst SSA's size in terms of land mass, diversity in topography, climate, and peoples make generalisations impossible (Toulmin, 2009), its dependence on natural resources, lack of climate change awareness and technical expertise, in conjunction with low capacity to cope with climate shocks, highlight several sources of vulnerability (Parry et al., 2007, Schneider and Lane, 2006, Toulmin, 2009).

Rain-fed agriculture across SSA is particularly sensitive to changes and variability in climate (Müller et al., 2011) and the recent IPCC (2014c) report states that it is 'likely' to be impacted by future climate changes. At the same time, human populations in SSA depend on rain-fed agriculture as a source of food, livelihood, economic growth and development (World Bank, 2007). Additionally, the agricultural sector accounts for 32% of Gross Domestic Product (GDP) in the region and employs more than 65% of the labour force (World Bank, 2007).

Work has been conducted into assessing impacts of climate changes on a range of crops (Challinor et al., 2014b, Schlenker and Lobell, 2010, Walker and Schulze, 2008) and livestock (Thornton, 2010, Thornton et al., 2009b) at various spatial scales (Thornton et al., 2011, Liu et al., 2008, Parry et al., 2004). A recent review of existing climate impact assessment studies highlight that the risks for agriculture in SSA vary according to the type of assessment model used (Müller et al., 2011). A recent study comparing maize yields in 2050 with a 2000 baseline revealed increases of 25% using one model, compared with yield decreases of 25% using another (Bashaasha et al., 2012). This demonstrates that some uncertainties around future crop yield projections can come from the models themselves (Challinor et al., 2009) and shows high levels of uncertainty in general surrounding future climate impacts on agricultural productivity (Challinor et al., 2014b). However, meta-analyses have been conducted to identify reoccurring findings across the published literature (Müller et al., 2011, Schlenker and Lobell, 2010), for example, they identify significant yield reductions across SSA for the second half of the 21st century (Challinor et al., 2014b, Knox et al., 2012). Potential yield reductions highlight the need for adaptations that reduce negative impacts and/or enhance positive impacts of climate change (Vermeulen et al., 2013, Lobell et al., 2008).

Mastrandrea et al. (2010) note that research linking climate impacts studies with adaptation planning is important. However, modelling studies simulating the impacts of climate changes on agricultural productivity focus largely on biophysical processes and variables such as crop growth and development, rainfall, and temperature (Challinor et al., 2014a). They often exclude human factors, such as management decisions and the factors that shape those decisions, which will be important in determining the actual impacts of future climate change (Easterling et al., 2007). Thus, models are widely criticized for leading to human-less projections of change (Fraser et al., 2011). Modelling approaches also fail to recognize that the natures of the farming systems that support the agricultural sector are complex, dynamic, and vary between and within countries. Furthermore, farming systems are not only economically productive systems; they also have important political, social and cultural dimensions (Tittonell, 2014). Current studies of climate impacts on agriculture poorly address this multi-functionality of smallholder farming systems (Binder et al., 2010), highlighting a need for further research in this area.

In practice, smallholder farming systems are social-ecological systems (SES) and comprise both biophysical and human components (Keating and McCown, 2001). SES, also referred to as human-environment systems or coupled human and natural systems, highlight that people and nature are interconnected and interdependent, thus making them analytically inseparable (Folke, 2006). To obtain a holistic understanding of SES and the potential impacts of climate change on them, interactions between human and biophysical components and the context in which they are embedded need to be considered (Berkes et al., 2003). Treating farming systems, also referred to as agro-ecosystems (Quinn et al., 2011, Conway, 1987), as complex SES provides one way of dealing with such interconnectedness.

1.3 Smallholder farming systems

Smallholder farming systems are intrinsically complex (Morton, 2007). Although a contested term, smallholder farmers are generally rural producers, usually living in developing countries, who predominantly rely on family labour, where the farm provides the principal source of livelihood (Cornish, 1998). In reality, smallholder farmers, sometimes referred to as subsistence or peasant farmers, sit on a continuum between subsistence production and market-oriented production (Morton, 2007), depending on the resource and institutional context in which they are situated.

Smallholder farming systems are situated in a wider context and comprise multiple individual farms, which are *“likely to have links (flows, synergies, dependencies etc.) to farms with dissimilar structure, as well as to non-agricultural and non-rural parts of the economy”* (Sumberg et al., 2013:1). In line with Dixon et al. (2001), this thesis recognises that individual smallholder farm systems sit within broader smallholder ‘farming systems’. An individual farm system refers to a household, its resources, and the resource flows and interactions at the individual farm level (Dixon et al., 2001). Farming systems are *“[a] population of individual farm systems that have broadly similar resource bases, enterprise patterns, household livelihoods and constraints, and for which similar development strategies and interventions would be appropriate.”* (Dixon et al., 2001:1). However, Giller (2013) acknowledges the diversity of interactions, and interdependencies of individual farm systems, thus challenging the homogeneity of the ‘farming system’ (Dixon et al., 2001). Farming systems are also embedded within a broader biophysical, social, economic and institutional context, where farmers have limited control or influence. Using a mixed-methods, multi-level approach, as adopted in this thesis, provides a way to explore links between individual farm systems, systems of farming and broader farming systems (Sumberg et al., 2013).

Approaching farming systems as SES recognises that biophysical processes interact with human and management components to define the characteristics of the farming system (Keating and McCown, 2001). Smallholder farming systems can be characterised by a range of sub-systems: crop production, livestock production, other agricultural/and or natural resource based activities, and non/agricultural or off-farm activities (Dixon et al., 2001). Such sub-systems depend on a range of system inputs, for example land, seeds, labour, as well as decisions about how these resources are used and allocated. Various biophysical and human processes, including climate change, thus shape farming system structures and functioning. Such processes are dynamic and operate across multiple temporal and spatial scales, and from the individual farmer to the global level.

Chambers (1997) recognises that people (in this case smallholder farmers) are at the centre of farming systems. Through on-farm decision-making and management practices, smallholder farmers implement particular systems of farming (Sumberg et al., 2013), also referred to as agricultural practices. Systems of farming are influenced by interactions between the farm household (preferences, priorities, experiences and histories), the farm (agro-ecology and productive resources such as land, machinery, livestock) and the wider biophysical, social, economic and institutional context (Darnhofer et al., 2012)., which will be captured in this thesis.

Farmers are the central agents in decision-making, where they have direct control over their management decisions, including resource allocation, which then characterise their 'system of farming' (Sumberg et al., 2013). This assumes that farmers can make conscious choices as individuals or groups (McGinnis and Ostrom, 2014), and such choices can, at least potentially, influence other factors to varying degrees. For example, farmer decisions can directly influence the way that resources are allocated, but they may have limited control over factors operating at larger scale, for example, the climate. Importantly, on-farm decision-making is influenced by multiple factors across spatial scales and may require temporal trade-offs between short term productivity and longer term sustainability (Giller et al., 2006). This highlights important temporal and spatial dynamics of farming systems and trade-offs which will be explored in this thesis.

1.3.1 Approaches to understanding smallholder farming systems

Farming systems research (FSR), later termed 'Farming Systems Adaptive Research' (FSAR) evolved during the 1970s in response to the low rates of technology adoption amongst smallholder farmers in developing countries (Sands, 1986). FSR was expected to enhance decision-making processes and better reflect farmer priorities by fostering participation. It has since been described as the beginning of a radical shift from top-down views of agricultural development towards a more holistic perspective (Dixon et al., 2001).

Recent FSR comes in many guises and labels (Darnhofer et al., 2012) and is increasingly seen as a catch-all (Sands, 1986, Noe and Alroe, 2012). Current farming systems studies tend to model resource flows and biophysical processes, and focus on quantitative lines of enquiry (for example Walker and Schulze, 2008, Rodriguez et al., 2014, Cortez-Arriola et al., 2014). Such studies overlook the multi-functionality and human dimensions of farming systems (Klapwijk et al., 2014, Mori et al., 2013, Kremen et al., 2012).

Darnhofer et al. (2012) suggest that three characteristics define current FSR: i) interdisciplinary approaches, ii) systems thinking, and iii) participation. Whilst conceptual understandings of smallholder farming systems are advancing, the literature provides few empirical studies that explicitly attempt to apply this conceptual understanding to generate empirical data. This thesis will directly target this gap. Moreover, only a limited number of empirical studies use both qualitative and quantitative methods to consider the interactions between human and biophysical components of the farming system (e.g. Dougill et al., 2010). This thesis builds on such approaches.

1.4 Smallholder farming systems, adaptive capacity and adaptation in sub-Saharan Africa

There are growing concerns that smallholder farmers across SSA, who depend on rain-fed agriculture as their main source of livelihood, may not possess the necessary capacity to cope with and adapt to current and future climate impacts. Even without projected climate changes, farming systems in SSA face a number of challenges to do with water supply, soil degradation, and recurring drought events (Mendelsohn, 2000). This places smallholder farming systems in a particularly vulnerable situation (Parry et al., 2007) and justifies the case for more research aimed at strengthening the adaptive capacity of farming systems across SSA.

Vulnerability is commonly conceptualised in the climate change literature as a function of exposure, sensitivity and adaptive capacity. Future climate projections and impact assessments suggest that smallholder rain-fed agriculture will be both exposed and sensitive to future climate changes, and that smallholder farmers in the developing world lack adaptive capacity. For example, they may lack the institutional support to adequately access the appropriate technologies, knowledge and resources required to tackle challenges presented by future climate change (Rodima-Taylor et al., 2012).

Research into the human dimensions of environmental change demonstrates that historically, smallholder farmers, through their management decisions, use of resources and preferences, have responded (or adapted) to multiple pressures and opportunities, including climate hazards (Thomas et al., 2007, Osbahr et al., 2010), extremes, variability and changes. Indeed, the persistence of such smallholder farming systems, despite multiple exposures to shocks and stresses, demonstrates a capacity to respond or adapt, i.e. adaptive capacity (Engle, 2011).

Adaptive capacity and adaptation research often focus on the present or the future, neglecting historical experiences of climate and other drivers of change. Climate change may present new climate hazards, including climate extremes and variability, and require new technologies, knowledge and resources. However, there is potential to gain useful insights from how smallholder farmers have mobilised their adaptive capacity to adapt to climate hazards; an aspect that is underexplored in climate change adaptation studies. This thesis examines historical experiences of exposure to climate hazards, and how households have operationalised their adaptive capacity to adapt to climate hazards.

Approaches that try to link past experiences with future climate change projections can be problematic due to the uncertainty of future changes and the extent to which they exceed past experiences (Thomas and Twyman, 2005). However, recent studies recognize the importance of current and historical factors in determining future climate impacts (Mastrandrea et al., 2010). Furthermore, current and future adaptation options are often contingent on historical pathways (Wise et al., 2014), where historical actions are recognised as potentially irreversibly constraining future adaptation options (Klein et al., 2014, Eriksen et al., 2011). This highlights important links between the past, present and future (Chhetri et al., 2010). However, empirical studies that explore and link past and present experience with future climate projections are lacking. Using farming systems in Uganda as a case study, this thesis addresses this gap. Such research can contribute to *"the paradox between views of present day helplessness and historical adaptability"* (Thomas et al., 2007:302) and provide insight into the prospects for future adaptations. Empirical findings presented in this thesis will also be drawn upon to generate insights into how adaptation planning can better support the adaptive capacity of smallholder farming systems.

1.5 Uganda

Studies have identified that Uganda is one of the top 10 out of 49 countries in SSA, highlighting that Uganda is vulnerable to climate change (Vincent, 2004). Data presented in Table 1.1, further demonstrate that Uganda can be considered as vulnerable to future climate changes in terms of increased exposure to future climate hazards (temperature increases, rainfall changes and increase in extreme events), high levels of sensitivity to such exposure (dependence on rain-fed agriculture), coupled with low levels of adaptive capacity (low levels of human development and high poverty levels). The United Kingdom (UK) Government's Department for International Development (DfID) has also identified Uganda as a priority country and suggest that it is particularly vulnerable to climate change and variability (Hepworth and Goulden, 2008).

Table 1.1 Vulnerability criteria applied to Uganda

Vulnerability Indicator	Proxy	Uganda	Source
Adaptive capacity	Poverty headcount ratio at national poverty line (% of pop. in 2005)	51.5%	World Bank (2009)
Adaptive capacity	Position on Human Development Index (out of 187)	164	UNDP (2014)
Sensitivity	% of GDP from agriculture	23%	World Bank (2009)
Sensitivity	% people involved in agriculture	80%	RoU (2007)
Sensitivity	% of land under irrigation	3%	FAO (2005b)
Exposure	Increase in temperature	Median increase of +1.5°C by 2030	Hepworth and Goulden (2008)
Exposure	Change in rainfall	Yes, but large uncertainties	Christensen et al. (2007)
Exposure	No. of extreme events	increasing	RoU (2007)

Climate change has been identified as a threat to smallholder farming systems in Uganda (RoU, 2007). Historically, Uganda has been exposed to multiple climate hazards, including climate extremes, variability and changes (Hepworth and Goulden, 2008). However, there is growing concern about how climate changes may impact upon Uganda and the extent to which the conditions will exceed historical extremes and ranges of variability (RoU, 2007). Additionally, projected changes in rainfall and temperature throughout the 21st century have the potential to undermine progress to date, and act as a barrier to further social and economic development (RoU, 2007).

Existing studies assess the impacts of future climate changes on the country's agriculture (Bashaasha et al., 2012, Hisali and Kasirye, 2008), with Uganda expected to become a hotspot of food insecurity (Liu et al., 2008). Yet, geographical variations in the nature of climate hazards across the country are not well understood. At the same time, farmers have experienced and responded to a range of climate hazards, including climate extremes, variability and incremental changes (Osbahr et al., 2011). However, limited empirical studies linking farmers' past experiences of climate hazards with projected climate changes exist, highlighting a need for additional research in this area.

A number of smallholder farming systems can be identified in Uganda, largely determined by the climate (e.g. rainfall patterns (total amount per year and the distribution)) and the range of agricultural activities being undertaken. For example, the Food and Agriculture Organisation (FAO) identify 'maize mixed' and 'highland perennial' as the dominant types of farming system in the country, with a much smaller 'pastoral' system in the far north eastern corner (Dixon et al., 2001). This study focuses on areas identified as part of the 'maize mixed' system, which covers 10% of the land area in SSA and 15% of the agricultural population in the region (Dixon et al., 2001). It has been described as "*the most important food production system in East and Southern Africa"* (Dixon et al., 2001:37). Therefore, findings from this Uganda case study could provide insights applicable across other farming systems in SSA, from neighbouring Kenya and Tanzania to Zimbabwe and Zambia.

Uganda has climate change projections, adaptation policies and agricultural policies, yet little is known about the relationship between these national level policies. Furthermore, there is limited understanding of how such policies interact with adaptation practices at the local level. This knowledge gap highlights that further work is needed to understand agriculture, adaptation and climate change policies and explore the impacts of such policies in practice. This thesis addresses this gap to advance understanding of these multi-level dynamics and generate insights into where support is needed to strengthen the adaptive capacity of smallholder farming systems across SSA.

1.6 Aim and objectives

The aim of this research is to advance understanding about smallholder farming systems, adaptive capacity and adaptation, to enhance adaptation planning in the context of climate change.

To achieve this aim, the objectives of the research are:

1. To explore trends in farming system evolution from the 1960s to 2012 and assess the impacts on farming system adaptive capacity;

2. To investigate household level responses to past climate hazards (changes, variability, and extreme events) over the period 1960 to 2012 and analyse how adaptive capacity has been operationalised;

3. To examine farmers' autonomous agricultural adaptations to 2030s rainfall scenarios and assess the extent to which such adaptations are supported by current policy;

4. To identify insights from using a mixed-methods, multi-level approach for adaptation planning.

How these objectives link together across different levels and points in time to contribute to the overall aim is presented in Figure 1.1.

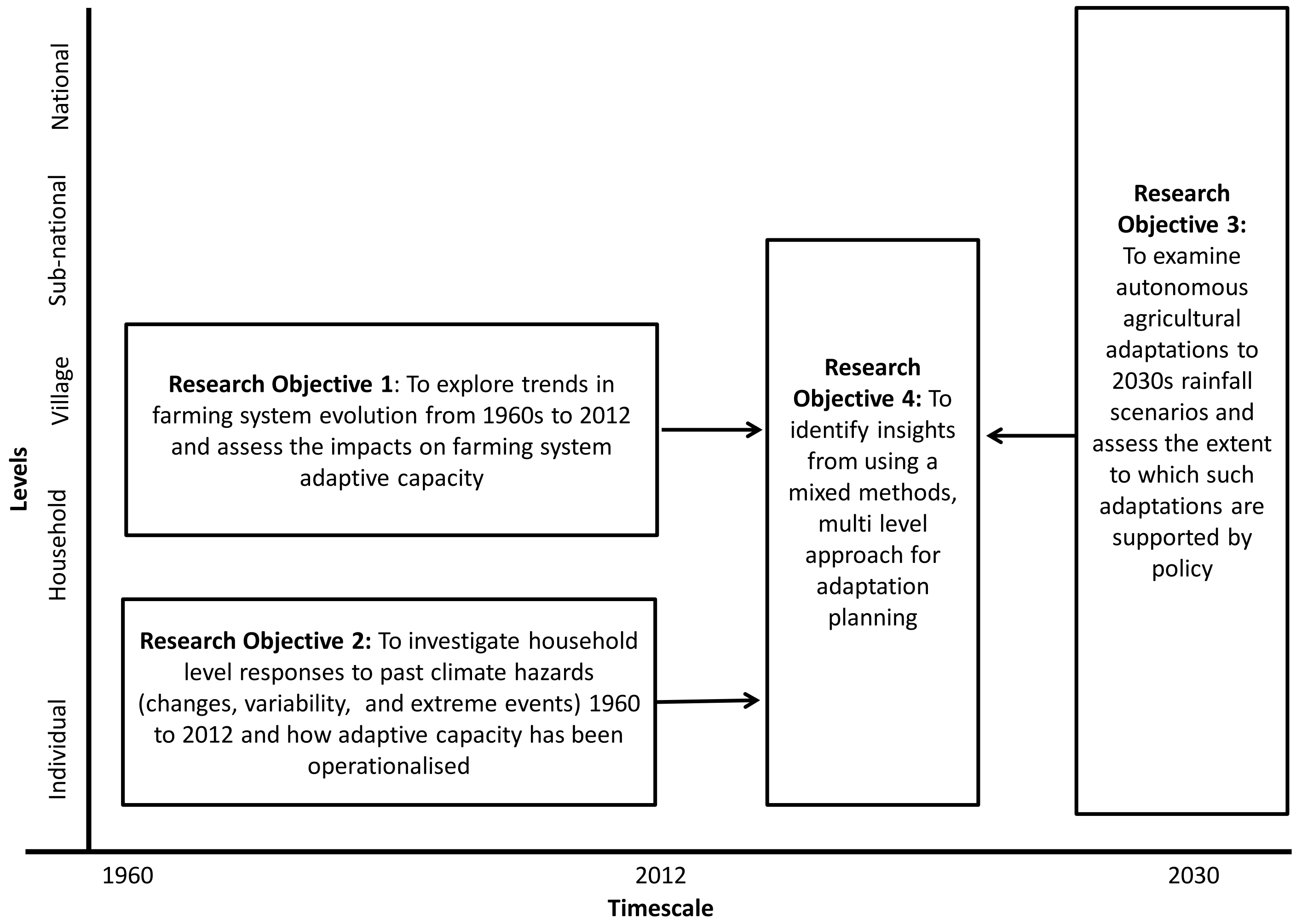


Figure 1.1 Overview of research objectives and how they link together over different levels and timeframes.

1.7 Thesis contribution

In addressing the research objectives, this thesis provides several important academic contributions, including new empirical data, an integrated conceptual framework and advances to understandings of adaptation and adaptation planning in the context of future climate changes. First, the research provides new empirical evidence about smallholder farming systems, adaptive capacity and adaptation through exploration of farming system dynamics across space and time. Such empirical evidence contributes to wider debates about the relationships between farming systems, farm systems and systems of farming. Second, findings contribute to our knowledge about how households draw upon and operationalise adaptive capacity in response to climate hazards. This increases understanding about the relationship between exposure to climate hazards and adaptive capacity and provides insight into how smallholder farmers may adapt to the challenges posed by future climate changes. Third, empirical findings of agricultural adaptation are presented in this thesis, alongside an analysis of adaptation in current national policies. This generates insights into the role of various decision-makers involved in adaptation and the trade-offs potentially encountered in strengthening long term adaptive capacity. Together such findings advance debates surrounding the definition and characterisation of autonomous and planned adaptation.

Informed by systems thinking, this thesis develops, applies and advances an integrated conceptual framework to advance understanding about farming system adaptive capacity. The farming system adaptive capacity (FSAC) framework highlights dynamic factors operating and interacting across space and time. It also integrates decision-making into systems thinking; thus recognising the capacity of individuals to act. It therefore contributes to our conceptual understanding about adaptive capacity and provides a framework for analysing complex SES.

In summary, this thesis combines a historical investigation of farming system evolution and household responses to climate hazards with agricultural adaptation to 2030s' rainfall projections, and a policy analysis, to generate insights for adaptation planning. To achieve this, it uses a combination of methods targeted at different levels and points in time. The methodological approach used is transferable and could be applied in other studies of SES. This thesis therefore, offers a novel methodological contribution to both farming systems and adaptation research.

1.8 Outline of thesis structure

This thesis is divided into nine chapters. Following this introductory chapter, Chapter 2 provides a critical literature review and explains key concepts associated with climate change, variability, adaptation, resilience, vulnerability and farming systems. Chapter 3 presents an overview of the research design, case study methodology and study area. An overview of the conceptual framework used to integrate the different elements of the thesis is also included in this section. Chapter 4 introduces and explains the data collection, methods and analysis procedures. A summary of methods specific to each research objective is provided in detail in the corresponding results chapters (Chapters 5, 6, 7).

Chapters 5, 6 and 7 present the results. Chapter 5, linked to research objective 1, explores how farming system evolution from 1960 to 2012 has influenced adaptive capacity. This chapter focuses on incremental changes over time as opposed to those associated with particular shocks and stresses. Results highlight the importance of farm-level decision making in shaping adaptive capacity. Chapter 6 focuses on climate hazards and addresses research objective 2. It explores how farm households draw upon adaptive capacity when exposed to climate hazards during the period from 1960 – 2012. Results demonstrate that an increasing dependence on market exchanges can reduce on-farm diversity. Building on findings from the historical analyses provided in Chapters 5 and 6, Chapter 7 uses future rainfall projections for Uganda in the 2030s, together with participatory methods, to explore agricultural adaptations undertaken at the farm-level. It also analyses adaptation in selected national agriculture, climate change and development policies to investigate the links between planned and autonomous adaptation. Results show that current agricultural policy in Uganda pays limited consideration to adaptation and does not support the range of autonomous agricultural adaptations undertaken by farmers.

Chapter 8 integrates the insights from Chapters 5, 6 and 7 and summarises the contribution of the thesis to understanding farming system adaptive capacity. The chapter outlines how each research objective has been achieved, followed by a synthesis of the empirical results chapters. It reflects on the mixed-methods, multi-level approach and demonstrates how such an approach can support adaptation planning. As well as providing a general discussion of how farming system adaptive capacity can be strengthened, it draws insights from research findings and outlines their implications for adaptation planning (Objective 4). Chapter 9 summarises the main conclusions and contributions. It provides recommendations and suggests avenues for future research.

1.9 Summary of Chapter 1

This chapter has described the research problem and outlined the research aim and research objectives that this thesis seeks to address. It has also stated the expected empirical and conceptual contribution of this thesis. It has described how thesis findings will contribute to wider academic debates about smallholder farming systems, adaptive capacity and adaptation in the context of future climate changes. Finally, it has provided an overview of the thesis structure.

Chapter 2 Literature review

2.1 Introduction to Chapter 2

The present chapter begins by examining climate change, variability and the impacts on agriculture. It then critically reviews literature on resilience, vulnerability, adaptive capacity and adaptation before focussing on climate change, agriculture and adaptation in SSA. Throughout this review, areas of contribution for this thesis are identified. This chapter also outlines the conceptual framework, developed from the literature review, that is used in this thesis to understand farming systems and adaptive capacity (Section 2.12). Material presented here is used to inform the research design (Chapter 3) and methods (Chapter 4). Focussed literature reviews specific to each research objective are presented at the start of each empirical results chapter (Chapters 5, 6 and 7).

2.2 Climate change and variability

Since the 1950s, an increasing rate of global warming has been observed, indicated by an increase in global mean surface temperature (IPCC, 2013c). Many of these observed changes, such as warming of the oceans and atmosphere, diminishing snow and ice, and sea level rise, are unprecedented over decades to millennia (IPCC, 2013c). A growing body of literature documents how global warming will affect future climate change and variability across a range of spatial and temporal scales (IPCC, 2013b).

Climate change is "*a change in the state of the climate that can be identified….by changes in the mean and/or variability of its properties, and that persists for an extended period, typically decades or longer"* (IPCC, 2013b:1450). Climate change can be the result of natural internal process or external forcing such as solar cycles, volcanic eruption and human activities that change the composition of the atmosphere. Climate variability is regarded as the variation in the mean state of the climate, beyond that of individual weather events (IPCC, 2013b).

The United Nations Framework Convention on Climate Change (UNFCCC) draws a distinction between climate changes attributable to human activities and climate variability as a result of natural causes. The IPCC asserts that it is extremely likely (95 – 100% certainty) that human influence has been the dominant cause of the observed warming since the mid-20th century (IPCC, 2013b). Therefore, climate change is used in this thesis to refer to both a change in the mean state of climate or in its variability due to natural or anthropogenic reasons (unless otherwise stated).

Global warming is projected to impact upon the climate system in a number of ways, leading to increasing temperatures, changes in precipitation, and increases in flooding, droughts and cyclones. Continued emissions of greenhouse gases will cause further warming and changes in the climate system (IPCC, 2013c). Regardless of the future emissions scenario and even if all concentrations of greenhouse gases are kept constant, global surface air temperatures and global mean precipitation are set to increase. However, changes in temperatures and precipitation will not be regionally uniform. For example, an increase in precipitation in tropical regions is expected, with a decrease in precipitation in subtropical regions (IPCC, 2007).

Climate changes are expected to create unprecedented impacts on natural and human systems. Current studies into these impacts identify those that are potential, i.e. all impacts that may occur without any form of adaptation; and those that are residual, i.e. impacts that could occur after adaptation (IPCC, 2007). In this thesis, 'impacts' will be used to refer to both potential and residual impacts. Distinction between different types of impacts will only be made where appropriate or necessary.

2.3 Climate impacts on agriculture

Research into the impacts of projected climate changes on agriculture has shown that crop productivity, indicated by crop yield, is highly dependent on weather and climate (Challinor et al., 2004) and there is a further positive relationship between crop yield and food security (Challinor et al., 2009). Large-scale relationships between climate and yield have been detected, with up to 50% of yield variability being attributable to climate (Challinor et al., 2003). Yet this 50% also demonstrates that the relationship between climate and agricultural production is confounded by other factors (Fraser, 2006). Mendelsohn and Reinsborough (2007) find that on average 39% of crop failure can be explained by climate and soil, leaving 61% which is unaccounted. Fraser et al. (2011) suggest that socio-economic and institutional or political factors could account for the other 61%. Yet, research to date into the impacts of climate change on agriculture has focussed on enhancing our understanding of the biophysical processes and on modelling such processes in order to make future predictions on a range of different temporal and spatial scales (Challinor, 2011, Challinor et al., 2004, Lobell et al., 2011). Such studies provide the current evidence for climate change policies (Fraser et al., 2010).

Impacts studies have been used to identify climate risk hot spots, vulnerable regions, sectors and peoples (Lobell et al., 2008). In recent years, maps depicting climate change hotspots have been increasingly used by researchers, advocacy groups and non-governmental organisations (NGOs) (de Sherbinin, 2014). There have also been attempts to mainstream the use of impact studies to inform adaptation policy in developing countries, for example in the development of National Adaptation Programmes of Action (NAPAs). 'Impacts driven' research focuses on the biophysical dimensions of future climate change (O'Brien et al., 2007), neglecting the complex dynamics that shape how climate changes are experienced (Ford et al., 2010). Such approaches can assume that local populations are passive victims of environmental change (Few, 2003). However, when it comes to determining the actual impacts of climatic shocks, e.g. floods and droughts, the social and ecological context is likely to be as important, if not more so, than the shock itself (Ericksen, 2008a, Turner et al., 2003). The same climate and biophysical processes can result in differential outcomes and involve the interplay of processes at different spatial and temporal scales. Impact assessments that ignore these factors are limited in their ability to assess the impacts of climate change and variability on SES, including farming systems, indicating a need for further research.

Capacity-approaches, such as those associated with vulnerability and resilience, are considered as alternatives to impacts-driven research; though the benefits of combining the two is increasingly recognised (Vermeulen et al., 2013). Capacity-approaches that start by assessing the existing capacities and vulnerabilities of individuals, communities or systems, provide other ways to understand the potential impacts of climate changes on SES.

2.4 Vulnerability and resilience

Vulnerability, broadly defined as the susceptibility to be harmed, is considered an existing characteristic of SES that is generated by multiple factors and processes. Vulnerability is conceptualised in the mainstream climate change literature as a function of exposure, sensitivity and adaptive capacity (Adger, 2006b, Parry et al., 2007). The combination of exposure to future climatic changes and a high level of sensitivity to climate, coupled with low adaptive capacity, makes a system, individual or community vulnerable to climate change.

'Vulnerability led' approaches emphasise the socio-economic and institutional processes that determine vulnerability of a system (Ford et al., 2010, Fraser, 2003, Fraser and Stringer, 2009, Stringer et al., 2009). Addressing current vulnerabilities, thus enhancing the ability of individuals, communities or systems to deal with multiple factors or processes, will reduce vulnerability under future climate conditions (Burton et al., 2002). Vulnerability-led approaches have been criticized for creating a potentially disempowering discourse, which fails to recognise the capacity of human populations to take action (Few, 2003). Using actor-oriented approaches to understand vulnerability promotes the inclusion of issues such as decisions, resource access and power and recognises the ability of individuals to act (Miller et al., 2010). One strategy to reduce vulnerability has been to increase the resilience of SES.

Resilience is argued to be a fundamental characteristic of both natural and human systems (Holling, 1973, Gunderson and Holling, 2002). The origins of the term imply strength and resistance, but in its more recent applications it is understood to require flexibility, learning and change (Miller et al., 2010, Adger et al., 2005a, Berkes et al., 2003). Resilience is not only an outcome which can be assessed or measured; it is also a process, i.e. the ability of an individual, system or community to absorb events, trends or disturbances in ways that maintain essential functions, identities and structures (IPCC, 2014c). However, resilience is not always desirable (Béné et al., 2014, Walker et al., 2006) and can act as a barrier to change, development and progress. For example, areas depleted of natural resources are extremely resilient to change but may provide little in terms of food or money (Vincent et al., 2013). Pelling (2011) proposes that resilience cannot be conceptualized as buffering or persistence alone, as that could reinforce existing practices that are ecologically or socially unjust and lead to the maintenance of the status quo. A stable system with highly polluted water supplies or governed under a dictatorship may be highly resilient, but unjust, undesirable or bear high economic and social costs (Stringer and Harris, 2014). Such examples demonstrate that resilience should incorporate the need for both stability and change (Folke et al., 2010, Duit and Galaz, 2008). In this thesis, resilience is understood to have three dimensions: persistence, adaptability and transformability (Folke et al., 2010, IPCC, 2014c).

While the literature demonstrates that there are relationships between resilience and vulnerability, they are not necessarily at opposite ends of the spectrum (Miller et al., 2010). This thesis draws on insights from vulnerability approaches and resilience thinking as ways to advance understanding about farming systems and adaptation in the context of future climate change.

Although rooted in different disciplines, numerous scholars recognize the potential linkages between vulnerability and resilience (Engle, 2011, Gallopín, 2006). Conceptual similarities and differences between the two terms can be found across the academic literature (Cinner et al., 2013, Miller et al., 2010, Gallopín, 2006). For example, both vulnerability and resilience can be viewed as being specific to a perturbation, highlighting that a system can be vulnerable to certain disturbances, but not others (Miller et al., 2010, Folke et al., 2010, Carpenter et al., 2001). This is also referred to as specified resilience, i.e. resilience of something, to something (Carpenter et al., 2001). Both vulnerability and resilience approaches recognise that social, economic, ecological and political processes shape how both climate, and non-climate changes, will be experienced (Fraser et al., 2010, Ford et al., 2010, Fraser, 2003).

Resilience thinking encourages systems-based approaches to analysing the interconnectedness and interdependency of human and natural components and processes of SES (Folke et al., 2010). Applied to SES, it emphasises the complex and dynamic relationships between human and biophysical components. Vulnerability-led approaches emphasise the social and institutional dimensions of vulnerability. This means that they can downplay the importance of ecological components. Cinner et al. (2013) highlight the importance of links between social and ecological dimensions and the feedbacks between the two.

Quinn et al. (2011) use concepts of diversity, connectivity and productivity to analyse the vulnerability of agro-ecosystems to drought. Such concepts are also found across the resilience literature. Fraser et al. (2011) assess the vulnerability of agro-ecosystems to environmental changes based on the capacity of the system to remain productive, the capacity of individuals to adapt based on access to resources, and the collective capacity to respond based on institutions, which are the formal and informal rules, norms and beliefs that govern behaviour and shape how individuals and organisations act and interact (Ostrom, 1990, Scott, 2001). What both Quinn et al. (2011) and Fraser et al. (2011) attempt to characterise is the capacity of the agro-ecosystem to adapt to change, i.e., its adaptive capacity.

Adaptive capacity, defined as *"the ability to adapt"* (Engle, 2011:648) has been identified as a common thread linking the vulnerability and resilience literature. However, differences emerge between how vulnerability and resilience literatures views exposure to hazards, also referred to as shocks, stresses, perturbations, events and incremental changes in the literature (Smit et al., 1999).

In the vulnerability literature, exposures are identified as threats and therefore have negative connotations. An alternative viewpoint is found in the resilience literature, where broadly resilience is the ability to bounce back following an external shock or stress (Resilience Alliance, 2010). In the resilience literature, exposure to a perturbation or stress, can strengthen the resilience of a SES (Holling, 1973). This suggests that in order to strengthen resilience, past exposure to shocks and stresses is crucial (Berkes and Folke, 2002). A similar viewpoint is proposed by the transitions literature, which recognises that hazards can present opportunities for transitions to new, more desirable states (Rose, 2011). Transitions following hazards can dislodge lock-in mechanisms and path dependencies, or eliminate a major basis for systems failure (Rotmans and Loorbach, 2009). When such changes happen, the ability of systems to learn from external shocks and long-term pressures is crucial (Foxon et al., 2009, Tompkins and Adger, 2003). Yet, empirical studies exploring the relationship between exposure and adaptive capacity as presented in the vulnerability and resilience literatures are lacking. Using empirical findings to provide insight into the dynamic nature of adaptive capacity, this thesis contributes towards addressing this gap.

2.5 Adaptive capacity

Adaptive capacity is generally accepted as a desirable property or positive attribute of a system for reducing vulnerability (Engle, 2011) and increasing resilience (Anderies et al., 2004). In the language of vulnerability, adaptive capacity can offset sensitivity to a perturbation (Cinner et al., 2013); in resilience terms it can enhance the robustness of a system (Anderies et al., 2004). Adaptive capacity can be translated into both practical actions and policy recommendations (Jones et al., 2010).

Adaptive capacity is a latent capacity, though a prerequisite for adaptation, where adaptation is defined in the broadest sense as *"a process of deliberate change, often in response to, or anticipation of, multiple pressures and changes that affect people's lives"* (Stringer et al., 2010:146). Adaptive capacity will be important in determining the actual impacts of future climate change and variability (Easterling et al., 2007). Work to date has focussed on defining or characterising adaptive capacity at various levels and scales (Brooks et al., 2005, Adger et al., 2004). This highlights that adaptive capacity is multidimensional: it is determined by complex inter-relationships between a number of factors at different scales (Vincent, 2007). Yet, limited research into the enabling and constraining factors currently exists. National indicators of adaptive capacity have been developed, but criticized for failing to capture many contextually relevant factors and processes; thus providing little insight at the level where most adaptations will take place (Yohe and Tol, 2002). In human societies, latent adaptive capacity requires sufficient resources and appropriate institutional structures (Yohe and Tol, 2002). Understanding of these aspects is therefore also vital.

Latent adaptive capacity assessments focus on availability of resources and consider the institutional processes that enable or constrain access to and utilisation of resources (Berman et al., 2012, Jones et al., 2010). Adaptive capacity in the vulnerability literature focuses on what enables a system to adapt, i.e. the processes and functions that enable adaptive capacity. Jones et al. (2010) suggest that in this regard, decision-making and governance; the fostering of innovation, experimentation and opportunity exploitation; and the structure of formal institutions and entitlements, are important. Understanding adaptive capacity therefore requires recognition of the importance of tangible resources and intangible processes. These aspects are referred to in this thesis as resources and institutions.

Adaptive capacity in the resilience literature emphasises 'what a system does', to enable it to adapt, for example, the properties it requires. This demands approaches that move away from simply looking at the resources and institutions that enable a system to adapt, and move towards recognizing what a system does to enable it to adapt (WRI, 2009). Holling and Gunderson (2002) and Quinn et al. (2011) emphasise that productivity, connectivity and diversity are important system properties that demonstrate farming system adaptive capacity.

Whilst the number of conceptual frameworks used to research and understand farming systems is increasing, few frameworks specifically consider farming system adaptive capacity. Yet, this will be important in the context of future climate change and variability. This highlights that there is potential to bring together farming systems and adaptive capacity into an integrated conceptual framework.

Advancing the frameworks developed by Quinn et al. (2011) and Fraser et al. (2011), this thesis recognises that the capacities required to respond to change (resources and institutions) alongside the properties a system requires (productivity and diversity) are fundamental to overall adaptive capacity. Whilst resources and institutions can be considered to shape what a system has to enable it to adapt, i.e. the inputs to a system, productivity, diversity and connectivity are necessary properties that demonstrate that a system is capable of adapting.

2.6 Adaptation

The definition of adaptation applied in this thesis includes all dimensions of adaptation (Section 2.6): coping, adjustment and transformation (Béné et al., 2012). Coping responses are seen as a short-term, immediate response to reduce (climatic) risks, and are therefore a largely reactive response to climate hazards. Adjustment, also referred to as incremental adaptation, is concerned with adapting to longer-term or incremental trends, for example in the changes to the mean climate of an area. Transformation involves fundamental changes to system function, structure and/or identity (IPCC, 2014c). Pelling (2011), classifies adaptation into different phases. He identifies a period of absorptive resilience (i.e. bouncing back or coping); of transition (also referred to as adjustment, incremental, or transitional adaptation); or of transformation of a system structure, function or identity. Each phase of adaptation does not necessarily occur discretely and together the phases are conceptualised as being along a flexible continuum.

Coping is often considered to occur within existing institutional systems, whereas incremental adaptation can involve changes to rules, processes, structures and institutions that enable a system to continue functioning (Parry et al., 2007). Processes of transformation rely on human resources, such as the ability to learn and apply knowledge, and social resources, such as access to networks and strong leadership. Adaptation studies have been criticised for focusing on coping and incremental changes, with limited consideration of underlying processes or the need for transformational change (Wise et al., 2014, Bassett and Fogelman, 2013). Transformational changes may be required to respond to the future climate hazards, beyond the range of past experiences (Kates et al., 2012). Transformation may be gradual, resulting from the deliberate or incidental accumulation of incremental changes, or it could be abrupt and surprising (Darnhofer, 2014). Rickards and Howden (2012) identify two main forms of transformational adaptation in agriculture as involving a change in the location or change in goal/land use. Bassett and Fogelman (2013) propose that transformative adaptation requires a shift in political economic structures. Conceptualized in this way, transformation has the potential to address wider development and poverty challenges (Kates et al., 2012). However, opportunities for transformational adaptation may be difficult to identify and implement in advance because of uncertainties about climate change risks and adaptation costs and benefits (Kates et al., 2012, Rickards and Howden, 2012). Determining whether a response is an example of coping, adjustment, or transformation depends on the context in which they are observed (Vincent et al., 2013). As a result of this academic debate surrounding different levels of adaptation, in this thesis adaptation includes coping, adjustment and transformation.

The relationship between these different types of adaptation is fuzzy. For example, incremental adaptation may act to hinder transformation; what Darnhofer (2014) refers to as an incremental adaptation trap. A number of potential trade-offs are also identified in the adaptation literature. For example, trade-offs between: mitigation, adaptation and development (Suckall et al., 2014b); short term coping strategies and long term adjustments (Vincent, 2007); incremental adjustments and transformation (Kates et al., 2012); and productivity and sustainability (Giller, 2013). However, evidence based case studies about trade-offs are rare (Tompkins et al., 2013). Using a mixed-methods, multi-level approach in this research contributes to this gap. Empirical research into adaptation can advance our understanding of when particular types of adaptation are appropriate and when additional or different support may be needed. Therefore, this thesis will return to these debates in the discussion (Chapter 8) on adaptation planning.

Links between adaptation and other concepts discussed so far in the literature review (resilience, vulnerability and adaptive capacity) are presented in Figure 2.1. This thesis does not explicitly draw upon all of the concepts, but recognises that they exist and that they are related. Therefore, the purpose of Figure 2.1 is to outline the important concepts identified from the literature review, highlight the relationships between these concepts, and to show how they are understood to fit together in this thesis.

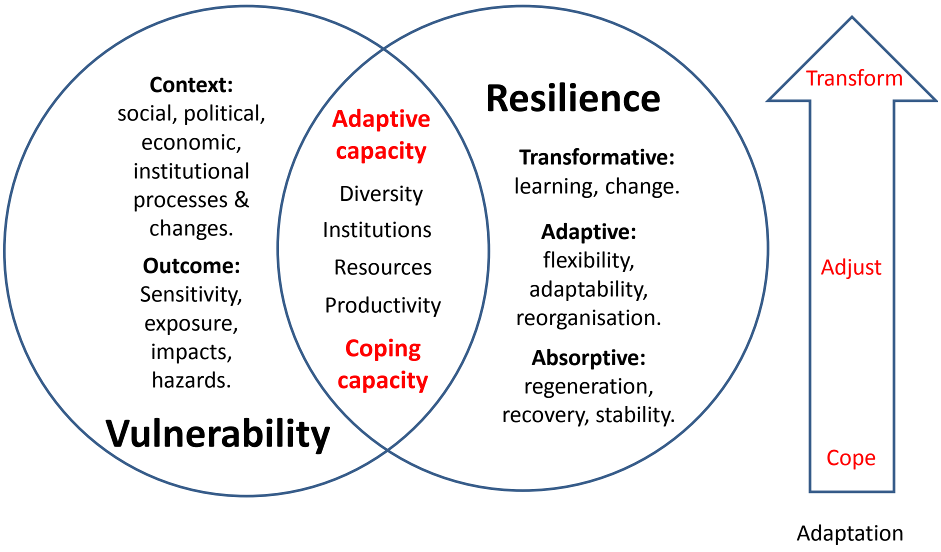


Figure 2.1 Linking resilience and vulnerability concepts through adaptive capacity, adapted from Béné et al. (2012), Berman et al. (2012) and Engle (2011). Concepts from adaptation literature are highlighted in red. Words in bold highlight distinctions in the literature between different types of vulnerability and resilience, where related words are also listed.

2.7 Climate hazards and adaptation

This thesis defines adaptation to climate hazards as *"an adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects which moderates harm or exploits beneficial opportunities"* (Parry et al., 2007:869). Such a definition encompasses past, actual or anticipatory responses, i.e. proactive and reactive measures. Reactive responses tend to be *ex-post*, following exposure to the hazard whereas active responses are *ex-ante* in anticipation of exposure. Climate hazards include all climate-related external stresses, pressures, risks, shocks, perturbations, events and changes. Where necessary in this thesis, distinction will be made between different types of climate hazard.

Climate hazards can be divided into: climate extremes; climate variability, and climate changes. Climate extremes refer to particular events (periods of time) or the physical impacts related to very high or low rainfall and/or temperatures (Mubiru et al., 2012). Such hazards can occur quickly in their onset, as is often the case with floods, or develop slowly, as is often the case with droughts. Climate variability can be measured by rainfall and temperature variations as compared to a long-term mean. This requires either a baseline or knowledge about the mean climate. Climate changes refer to mean weather trends over a period of time, which are also calculated using a baseline or knowledge of a mean climate (IPCC, 2007). Trends are incremental changes that happen over a period of time and are not linked to a particular event, for example an increase in mean temperatures. Climate hazards are also referred to as drivers, pressures, shocks, stresses, perturbations, and stressors (Smit et al., 1999).

Climate hazards can be covariate, where the impacts are felt across a community, such as in the case of droughts, or idiosyncratic, where certain individuals or households experience the impacts, such as in the case of localised flooding. Existing case studies suggest a relationship between the nature of the climate hazard and adaptation (Berman et al., 2014). However, these relationships remain underexplored, highlighting a need for further work in this area.

It is widely recognised that adaptation is needed to reduce the impacts of climate hazards in SSA (IPCC, 2014c). Adaptation is generally understood to involve alterations to a system in response to an external stress, pressure, opportunity, risk, shock, hazard, perturbation, event or change (Smit and Wandel, 2006). It is described in the literature as both a process and an outcome. Whilst adaptation is a complex, messy issue (Head, 2014), adaptation to climate hazards is not new (Pielke et al., 2007, Thomas et al., 2007, Agrawal, 2008). Individuals and communities, including farmers, have adapted to a range of climatic and non-climatic hazards, through their livelihood choices, use of assets and preferences (Rodima-Taylor et al., 2012, Adger et al., 2005b). This demonstrates that there is considerable potential to gain insights from exploring past adaptations to climate hazards. Past adaptations provide a starting point for understanding how farmers may adapt in the future (Vogel et al., 2007). Furthermore, to advance understanding of such linkages requires empirical studies that examine links between the past, present and future (Vincent et al., 2013). This thesis explicitly targets this gap.

Existing empirical research demonstrates that adaptation to climate hazards is not necessarily distinct from adaptation to other hazards (Thomas and Twyman, 2005, Osbahr et al., 2008a), highlighting that adaptation is driven by both climatic and non-climatic pressures and opportunities (Osbahr et al., 2010, Stringer et al., 2010). Indeed, climate adaptation research has also explicitly noted the interaction between climatic and non-climatic drivers of adaptation (Moser and Ekstrom, 2010). Such findings confirm the importance of defining adaptation in the broadest sense and understanding the context in which adaptation takes place, where climate is not the only driver of adaptation (Pielke et al., 2007, Bisaro et al., 2010). This thesis provides empirical evidence about past and current adaptations to climate hazards to generate insights that enhance our understanding of adaptation.

2.8 Climate change, agriculture and adaptation in sub-Saharan Africa

Long-term rainfall trends from 1900 to 2005 have been observed over many regions, with drying trends noted in many parts of SSA (IPCC, 2013b). Climate change projections for the 21st century suggest that it is very likely (90% probability) that there will be long-term temperature increases of around 0.2^{o}C per decade during this century (IPCC, 2007). It is also very likely that rainfall amounts and patterns will change across SSA, while it is likely (66% probability), that there will be an increase in the number and strength of extreme weather events, such as droughts, floods and storms across the region (IPCC, 2007). In summary, climate projections for SSA suggest that temperatures, rainfall variability and the occurrence of extreme events will increase (Niang et al., 2014).

Results presented by Liu et al. (2008) demonstrate that 2030s' climate changes in SSA could lead to an increase in crop yield of 2-3%. However, aggregate results for SSA hide variability between and within countries, and between different crops and varieties (Jones and Thornton, 2003). For example, 2030s' climate changes could lead to wheat yields in SSA that are 16-18% lower, but millet yields that are 7-27% higher when compared with a 1990s baseline (Liu et al., 2008). Jones and Thornton (2003) estimate that as a result of temperature increases and rainfall differences, overall maize yields across SSA will decrease by 10% by 2055 when compared with a 1990 baseline. They also highlight areas where maize yields will increase and where yields may change more substantially (Jones and Thornton, 2003). Such findings demonstrate that climate change will present both challenges and opportunities for agriculture in SSA, which suggests that adaptation is necessary to reduce harmful impacts and take advantage of opportunities.

2.8.1 Livelihoods and adaptation

Existing case studies have examined farmer responses to climate hazards across SSA (Deressa et al., 2009, Below et al., 2010) and within Uganda (Hisali et al., 2011). Some of this research focuses on specific climate hazards (Roncoli et al., 2001), specific levels, e.g. household level (Berman et al., 2014) or specific sectors, such as agriculture (Vincent et al., 2013, Deressa et al., 2009, Bryan et al., 2009). Evidence suggests that households can bounce back quickly from exposure to hazards if they can remobilise resources in a timely way, such as being able to buy seeds and replant directly after a flood. In such situations, households might draw upon other livelihood activities (e.g. farmers may seek casual work opportunities in exchange for cash or food during a drought, if agricultural production is negatively affected). This demonstrates that diverse livelihoods can help absorb hazards through asset switching and substitution, bouncing back from disturbance through asset mobilisation, without being fundamentally changed. This represents a household coping or adjustment response and, demonstrates adaptive capacity.

Farmers have historically experienced a range of climate hazards, resulting in livelihood adaptations. The Sustainable Livelihoods Framework (SLF) is increasingly used to understand how people adapt their livelihoods to and cope with a range of hazards, including those linked to climatic hazards (Scoones, 1998). Livelihood adaptation to climate hazards has been extensively explored within the literature, including numerous studies that have focused on SSA (Antwi-Agyei et al., 2014, Conway and Schipper, 2011, Osbahr et al., 2008b, Thomas and Twyman, 2005). Future climate change and variability has the potential to have significant and detrimental effects on livelihood activities, unless adaptations are undertaken that prevent loss of the asset base.

Livelihood activities are broadly defined as a means of making a living (Chambers and Conway, 1991). Livelihood activities are influenced by multiple factors, including the goals of a particular individual or household. Although these goals are determined at a household level, they are informed by socio-cultural and socio-economic factors situated in the wider economic, political and institutional context. Contextual factors also shape livelihood adaptation. Time also influences the nature of livelihood adaptation (Vincent et al., 2013). Thus, livelihood adaptation is a process influenced by a range of economic, political and social factors, operating and interacting across a range of temporal and spatial scales (Osbahr et al., 2010).

The SLF acknowledges the importance of access to human, financial, social, physical and natural assets, which this thesis refers to as resources, in shaping livelihood activities (Scoones, 1998). Use of resources underpins the livelihood activities that households use to make a living but can also be drawn on to cope with and adapt to hazards (Bebbington, 1999). The ways in which resources are accumulated, used or substituted all contribute to the ways in which households manage pressures and opportunities. For example, households may draw upon social capital to ask friends or family for assistance in response to a particular climate hazard, but this does not necessarily reduce the availability of that resource at other times and for other purposes. However, other resources can be depleted through their use or consumption, for example, spending savings or selling livestock. This demonstrates that using and consuming resources can restrict livelihood activities and thus limit future adaptation options.

Livelihood activities are also influenced by certain formal (e.g. property rights) and informal (e.g. trust and reciprocity) institutional arrangements. Institutions are defined here as the rules, procedures and norms that shape expectations, guide behaviours and interactions (North, 1990, Ostrom, 1990), and also shape the rights and responsibilities of individuals or organisations (Young, 2002, Ostrom, 1990). Agrawal (2008) also distinguishes between market/private, public/government and communal/civic institutions. Institutional structures and processes can affect smallholder farmers' utilisation of their different capital assets (Scoones, 1998). Institutions are also known to be important in framing access and entitlements to resources, which in turn shapes livelihood activities (Chambers and Conway, 1991), as well as coping and adaptation options (Berman et al., 2012).

Attempts have been made to classify livelihood adaptation. Combining work of Agrawal (2008) and Vincent et al. (2013), this thesis recognises that livelihood adaptation strategies can be classified into six major types: (1) mobility, which spreads risks across space; (2) storage, which spreads and reduces risks over time; (3) livelihood diversification, where increasing the portfolio of activities and resources reduces risks across resources owned by households or collectives; (4) common pooling, which pools risks across households in local communities; (5) market exchange, which includes financial transactions; and 6) agricultural modification, which refers to changes in agricultural management practices, capturing the adjustments to systems of farming. Agricultural modification includes a range of agricultural adaptations. Such classifications can be used to analyse adaptation to past and future climate hazards (Berman et al., 2014, Wang et al., 2013).

2.8.2 Agricultural adaptations

This thesis recognises that across SSA, a range of livelihood adaptations exisit. This thesis considers both past and present livelihood adaptations (Chapter 6) and specifically focuses on agricultural adaptations (Chapter 7). Agricultural adaptations form part of wider livelihood activities and are influenced by access to resources. They can enable farm households to manage hazards and will therefore be important in determining the future impacts of climate hazards on smallholder farming systems (Herrero et al., 2014). Additionally, understanding how smallholder farmers can adapt to future changes is critical if poverty alleviation and food security goals are to be achieved (Challinor, 2008).

Smallholder farmers across SSA use locally-held knowledge and experience of a 'normal' climate in making management decisions throughout the agricultural season. Rainfall changes in future may present climatic conditions that are beyond the range of farmers' historical experiences. However, limited studies have explicitly explored how farmers may adapt their agricultural practices to future rainfall scenarios. Understanding this may provide insight into autonomous agricultural adaptations to 2030s' climates, while incorporating farmers' knowledge and experiences into current adaptation policies may lead to the development of adaptation strategies that are appropriate, cost-effective, participatory and sustainable (Tschakert and Dietrich, 2010, Raymond et al., 2010, Stringer et al., 2009).

An emerging body of literature is examining current agricultural adaptation strategies (Herrero et al., 2014, Wood et al., 2014, Mapfumo et al., 2013). Such studies confirm that farmers use a range of agricultural adaptations to respond to both climatic and non-climatic hazards, which is not reflected in studies of climate impacts on agriculture, where adaptation is most commonly defined as a change in planting date or switching to a different crop variety (Lobell, 2014). How and why particular adaptation decisions are made remain underexplored. This thesis will therefore contribute to this body of knowledge by specifically examining a range of agricultural adaptations, also referred to as agricultural modifications, which as explained in Section 2.8.1, tend to be considered as one type of livelihood adaptation (Wang et al., 2013). Agricultural modifications relate specifically to on-farm changes in agricultural practices, and can be further categorised under four headings, specifically: intensification, extensification, diversification and specialisation. Focussing on agricultural adaptations in Chapter 7 will provide insight into how smallholder farmers may adapt to future climate change and variability.

2.8.2.1 Intensification and Extensification

Intensification was described by Boserup (1965) as an endogenous process used to respond to population pressures and can involve allocating more resources to the same activity to maintain the same or improved returns (Suckall et al., 2014b). Intensification and extensification are used in this thesis to refer to on-farm adaptations. On-farm intensification can be calculated using the ratio of the amount of crops (e.g. number of crops) cultivated on a specific area (e.g. number of hectares). Therefore, intensification can be a result of planting the same amount of crops, but reducing the area cultivated, or by increasing the amount of crops cultivated without increasing the area. Intensification can be achieved by planting high yielding varieties, fertiliser and irrigation (Carswell, 1997), or can occur by allocating more labour to crop cultivation. Extensification is the opposite of intensification. On-farm extensification refers to a process of either increasing the amount of cultivated land or reducing the amount cultivated on a specific area. Farmers can practice both intensification and extensification through either diversification or specialisation (Herrero et al., 2014).

2.8.2.2 Diversification and Specialisation

Smallholder farming systems found across SSA tend to be highly diverse (Herrero et al., 2010). The degree of diversification can be considered at different levels and scales. At the household level, livelihood diversification, defined as "*the process by which (rural) households construct an increasingly diverse portfolio of activities and resources in order to survive and to improve their standard of living*" (Ellis, 2000: 14), has received extensive interest within the literature (Goulden et al., 2013, Eriksen et al., 2005, Nielsen and Reenberg, 2010). Diversification is a livelihood strategy, for example it can include increasing the range of livelihood activities, changing activities, and household members migrating to take on additional activities elsewhere (Goulden et al., 2013). Increasing attention is being paid to the effectiveness of using livelihood diversification to adapt to climate hazards (Berman et al., 2014). However, little is known about the role of on-farm diversification in adapting to climate hazards as most studies tend to look beyond the farm.

On-farm diversification can be identified by examining the range of agricultural activities (e.g. both crops and livestock), or by observation of increasing on-farm agricultural activities (e.g. planting of new crop varieties). The process of on-farm diversification is reversed if the range of agricultural activities is reduced, or if the range of crops and/or livestock is reduced. This process is referred to as specialisation. Specialisation can occur to take advantage of opportunities such as market access or as an involuntary response to a situation, for example inadequate access to seeds. Specialising in a particular crop or breed can result in concentrating risk, which is contrary to the risk spreading benefits of on-farm diversification that is often used by smallholder farmers (Ellis, 2000).

2.9 Autonomous and planned adaptation

Historically, smallholder farmers across SSA have adapted to a range of climatic and non-climatic pressures and opportunities (Section 2.8). Such adaptation is described as autonomous, i.e. an automatic, spontaneous or passive response (Forsyth and Evans, 2013). Autonomous adaptation is not a conscious response to climatic stimuli, instead it can be triggered by a change (or a number of changes) in human or biophysical systems (Parry et al., 2007). Research suggests that a variety of autonomous agricultural adaptations, such as shifts in crop varieties and land use, are taking place. However, in practice such adaptations are influenced by a range of contextual factors, and the wider policy context (Stringer et al., 2010), making it difficult to understand what distinguishes autonomous adaptation from planned adaptation.

The climate change adaptation literature suggests that a distinction between planned and autonomous adaptation can be made and that given future climate changes, it is essential to examine how planned adaptation can help or hinder autonomous adaptation. At the same time, the literature recognises that planned adaptations intending to facilitate autonomous adaptation do not always provide effective support (Stringer et al., 2010). This demonstrates that autonomous adaptation can be both supported and undermined by planned adaptation. The idea of autonomous adaptation supported by planned adaptation may sound like an oxymoron, highlighting the need to clearly define such terms, which will also contribute additional insights into the relationship between planned and autonomous adaptation.

In this thesis autonomous adaptations are understood to be undertaken by individuals, household or communities at the local level, whereas planned adaptation refers to deliberate policy decisions and activities that explicitly consider climate changes, such as when designing infrastructure or developing agricultural technologies. Such policy decisions and activities may also facilitate autonomous adaptation at the local level (Parry et al., 2007). This suggests that the deliberate attempt to consider climate changes and the level at which the decision takes place are defining features of planned adaptation. This thesis also distinguishes between planned adaptation and adaptation planning. Planned adaptations are tangible policies, decisions or activities, whereas adaptation planning informs the decisions about who should do what, when and with what resources that may result in a planned adaptation (Füssel, 2007).

Adaptation planning is part of the process that can inform planned adaptation and therefore requires consideration of both adaptation policy and practice. Policy and practice are not precise, self-evident or fixed terms (Urwin and Jordan, 2008). Policy is used in this thesis to include declarations, strategies or plans, as well as the results of such policies on the ground (Court and Young, 2003). Given that this thesis focuses on adaptation in the context of farming systems in Uganda, policy is used to specifically refer to national level government policies relevant to adaptation, agriculture and development. Practice broadly refers to practical decisions, projects or actions that could be implemented by various decision-makers, including NGOS and farmers.

Both planned and autonomous adaptation may reduce short-term impacts but inadvertently increase vulnerability to other risks or other longer term changes; actions that are not sustainable can be termed a maladaptation (Vincent et al., 2013). For example, autonomous adaptation may hinder longer term development and climate change mitigation goals, suggesting that without planned adaptation, maladaptation could occur (Suckall et al., 2014b). For example, planting in low lying swamps may reduce the impacts of a drought to maintain yields in the short term, but can also lead to siltation which then undermines the natural resource base and can therefore increase exposure to future flooding (Vincent et al., 2013). At the same time, planned adaptation can have a range of intended, unintended and negative impacts, including undermining autonomous agricultural adaptation. This thesis recognises that not all planned or autonomous adaptations are positive or beneficial (Lobell, 2014) and that in some cases, they can lead to maladaptation across both space and time (Barnett and O'Neill, 2010).

Current decisions, whether planned or autonomous, may irreversibly constrain future adaptation (Klein et al., 2014, Eriksen et al., 2011). Existing literature highlights that decisions that lead to a reduction in adaptation options potentially undermines future adaptive capacity. For example, if a decision constrains choices to a smaller set of adaptation options it can remove flexibility, thus creating a lock-in effect (Fazey et al., 2009). This emphasises the important links between the past, present and future and demonstrates the relevance of combining historical analysis with forward-looking studies of adaptation, as used in this thesis.

Lock-ins emerge when a system has few adaptation options and therefore low potential for change (Allison and Hobbs, 2004). Lock-ins can be of various kinds and take various forms (Darnhofer, 2014). They can be functional, cognitive, or financial and reflect vested interests (Schoon et al., 2011, Allison and Hobbs, 2004). Lock-ins not only increase the risk of maladaptation, they may also create a further barrier to transformation. Lock-ins may be created by reduced diversity of adaptation options (Fazey et al., 2009), demonstrating that having a range of adaptation options may avoid lock-ins, enhance adaptive capacity and avoid maladaptation (Wise et al., 2014). For example, farm households engaged in large number of agricultural and non-agricultural activities tend to be better off than those that are engaged in fewer (Thornton et al., 2007). Having a diverse range of adaptation options can also be an indicator of resilience (Kahiluoto et al., 2014) and may provide a way to strengthen resilience (Fazey et al., 2009). This demonstrates that response diversity can be promoted as a way to maintain a range of adaptation options; thus potentially increasing resilience (Butler et al., 2014) and reducing the risk of lock-in (Wise et al., 2014). However, empirical evidence to support this is lacking. In order to contribute to such debates, this thesis will investigate the relationships between diversity, farming systems and adaptation and draw out the implications for adaptation planning.

2.10 Unpacking policy interactions

Existing studies demonstrate that the relationship between autonomous adaptation and planned adaptation is complex. Yet, few studies have explicitly examined the relationships between autonomous adaptations, planned and other policies. Policies at different levels and across different sectors influence human and environment interactions. Such policies may fall beyond the scope of a specific planned adaptation, yet they may influence the impact of any planned adaptation, or indeed shape autonomous agricultural adaptations. It is necessary to consider such policy interaction, i.e. the relationships between two or more policies (Kalaba et al., 2014). Empirical findings presented in this thesis will address this by focussing on interactions between autonomous agricultural adaptations, planned adaptation and agricultural policies.

Interaction can occur at the same or across different governance levels and can involve positive, negative or neutral interactions (Young, 2006). Policies can also have impacts at different scales, for example incentivising and dis-incentivising certain types of behaviour and decision-making at a local scale (Cash et al., 2006). Policies designed at a national scale can have unforeseen positive and negative effects at local scales (Brooks and Adger, 2005). National level policies are embedded in a wider governance system, made up of numerous actors (policy makers), organisations (line ministries and other formal bodies) and institutions (formal and informal rules that govern behaviour).

Environmental issues such as climate change are often cross-cutting and ignore geographical, political and administrative boundaries. As such, they require cross-sector policy responses (Stringer et al., 2014). Adaptation policies are a relatively recent phenomenon. The UNFCCC requires developing countries to develop a NAPA. NAPAs identify priority activities that address urgent and immediate adaptation needs (UNFCCC, 2014b). Under the Cancun Adaptation Framework, NAPAs will be replaced by national adaptation plans which aim to identify medium- and long-term adaptation needs and support the development and implementation of strategies and programmes to address such needs (UNFCCC, 2014a). However, at the time of research, national adaptation plans (for Uganda) were still under development so are not analysed in this thesis.

The design and implementation of adaptation policies is relevant to existing sectors and both new and existing policies (Urwin and Jordan, 2008). The cross-sector nature of adaptation presents a challenge to traditional policy analysis approaches, which tend to analyse policies vertically across different levels of governance, rather than horizontally, across the same level of governance. (Young, 2002). Sector-specific policies interact and influence each other's effectiveness (Oberthür and Gehring, 2006). In the case of agriculture and adaptation in SSA, many of the key issues are linked to economic growth, poverty reduction and national development, and can thus be described as cross-sector. Cross-sector issues require a cross-sector approach to policy analysis, including consideration of specific adaptation and agricultural policies, as well as national development plans. Therefore, this thesis identifies and considers relevant national level agriculture, adaptation and development policies.

Policy will not only be instrumental in determining the costs of climate change (Patt et al., 2010) but policy and governance frameworks can both assist and hinder autonomous adaptation efforts undertaken by farmers (Stringer et al., 2009). This demonstrates the importance of identifying who current policy supports, how costs and benefits of various adaptation options may be distributed, and what trade-offs have been made (by whom, for whom etc.) (Adger et al., 2005c). Such questions will be addressed in this thesis by identifying areas of convergence and divergence between autonomous and planned adaptations, whilst recognising that both planned and autonomous adaptation can lead to maladaptation. By exploring how policies such as planned adaptation can support or hinder autonomous adaptation, this thesis provides insight into where policy changes may be needed, enabling the identification of areas for future research and recommendations to support adaptation planning.

2.11 Informing adaptation planning

Although there is burgeoning literature on the potential impacts of climate changes on crop yields (Challinor et al., 2014b, Hertel et al., 2010, Challinor, 2008, Mendelsohn and Dinar, 1999), such research has had a limited impact on adaptation planning (Mastrandrea et al., 2010). This thesis therefore, will use evidence to highlight the implications for adaptation planning at the sub-national and national level as well as drawing out some broader lessons (Chapter 8).

Information and levels of certainty generated by research can fall short of the standards required for decision-making for both policy and practice (Bradshaw and Borchers, 2000). For example, it may not provide information at relevant temporal or spatial scales. Literature highlights that 'users' of climate risk information, for example those involved in adaptation planning, are most interested in the next few decades (Wilby et al., 2009), therefore the 2030s were selected as the timeframe for analysis in this thesis. This timescale is appropriate for decision makers in Uganda given the nature of policy cycles, especially as the longest planning horizon for Uganda is 30 years. Uganda has an overall Comprehensive National Development Framework Policy (CNDFP) which provides a 30-year Vision to be implemented through three 10-year plans, comprising six 5-year National Development Plans (NDPs) and 5-year Sector Investment Plans (SIPs). IPCC (2007) projections for 2030 show similar results for the annual mean surface warming (°C) between 2011 and 2030 regardless of the Special Report Emissions Scenario (SRES), whereas from 2046 onwards the SRES plays a bigger part in determining the level of temperature change, therefore there is a larger range of possibilities. Furthermore, food security in Uganda could see a 50% increase in undernourished people by 2030s, unless increases in per capita agricultural productivity are realised (Funk et al., 2008), highlighting the importance of advancing understanding of adaptation over the selected time frame.

Evidence suggests that receiving information alone may not be sufficient (Patt and Gwata, 2002). Other factors, including the resources and capacity to act, influence the uptake of information by policy-makers and practitioners (Dessai et al., 2005). In order to proactively take steps towards this thesis generating potentially useful insights for adaptation planning, this thesis followed best practices for effectively channelling science into policy identified by Stringer and Dougill (2013). For example, this research process engaged both policy-makers and practitioners from the outset, where opportunities were sought to ensure timely information provision (Stringer and Dougill, 2013). Additionally, research findings were disseminates and communicated appropriately (Reed et al., 2014).

2.12 Conceptual framework

This section integrates concepts critically discussed in the literature review to present the conceptual framework that informed this thesis. This conceptual framework uses systems thinking as a way to integrate current understandings of smallholder farming systems, adaptive capacity, and adaptation.

2.12.1 The farming systems and adaptive capacity framework

In this thesis, a framework is defined as a set of assumptions, concepts, values and practices that constitute the way of viewing a situation (Binder et al., 2013). A number of studies provide conceptual frameworks for analysing SES (Whitfield and Reed, 2012, Rounsevell et al., 2010), and these have recently been reviewed (Binder et al., 2013). Frameworks that focus specifically on farming systems and adaptive capacity, however, are lacking. Furthermore, few studies attempt to link conceptual frameworks with empirical data.

Current understanding about farming systems and adaptive capacity was outlined in both this Chapter and Section 1.4, where the potential to further bring together these bodies of literature has also been identified. Literature demonstrates that both farming systems and adaptive capacity are shaped by interacting factors operating across multiple temporal and spatial scales (Peterson, 2000). Building on such understanding, this thesis presents a framework to advance understanding about farming systems and adaptive capacity (Figure 2.2). In line with existing literature, this farming systems adaptive capacity (FSAC) framework links the characteristics of farming systems with the factors that enable a system to adapt, i.e. the inputs a farming system requires, and the properties that demonstrate that a system is adapting, i.e. the system properties. The FSAC framework specifically recognises the importance of resources and institutions as system inputs, and productivity, connectivity, and diversity as system properties (Fraser et al., 2011, Quinn et al., 2011, Gunderson and Holling, 2002).

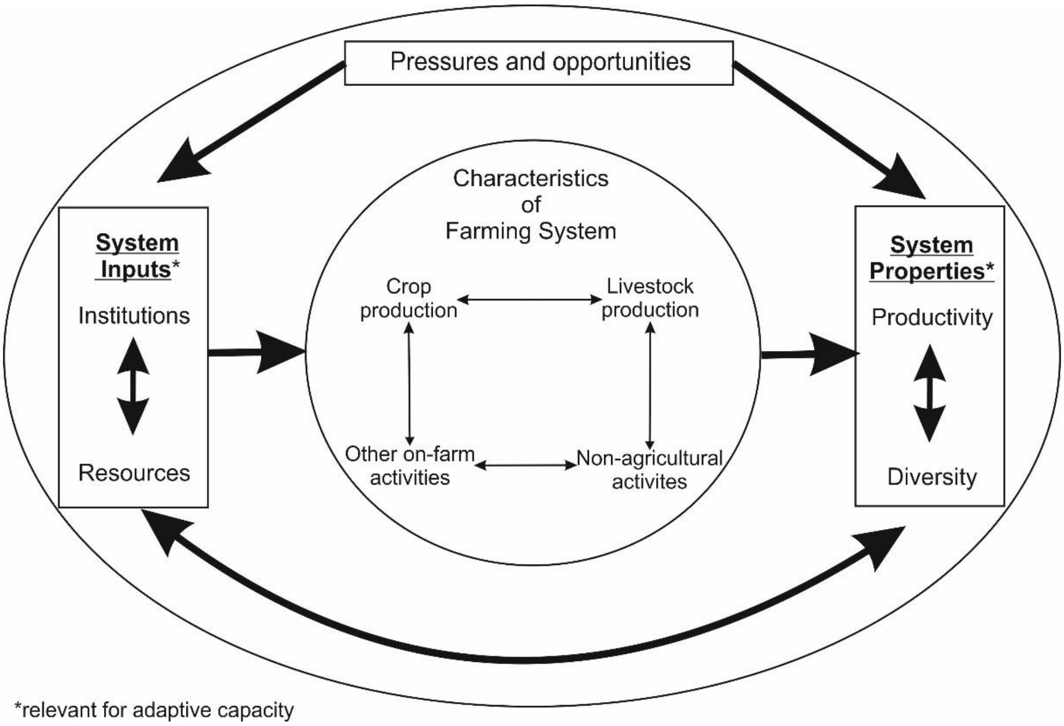


Figure 2.2 Integrated farming system adaptive capacity framework, bringing together the sub-systems that characterise a farming system with important components of adaptive capacity identified in the literature: institutions; resources; productivity; and diversity (Fraser et al., 2011, Quinn et al., 2011). System inputs both directly shape the characteristics of the farming system and indirectly effect system properties, productivity and diversity. Arrows are used to highlight interactions between inputs, properties, characteristics, and pressures and opportunities. Large double arrows highlight the relationship between components of adaptive capacity, and small double arrows show interaction between the characteristics of the farming system.

In the FSAC framework (Figure 2.2), resources refer to the natural, social, financial resources or the resources used as system inputs, for example labour. How resources are used to determine the characteristics of the farming system is influenced by informal and formal institutions operating across different levels. The characteristics of the farming system result in certain system properties such as productivity and diversity, which are also interrelated. Productivity is the accumulation of resources within a system that ensure it continues to function. Diversity, including diversity of crops, vegetation and livelihoods, captures the ability of the system to maintain functionality, whilst compensating for disturbances (Quinn et al., 2011). Connectivity, defined as the strength of internal connections, is considered part of institutions as these determine interconnectedness between parts of a system. Both inputs and properties are connected and are also influenced by external biophysical, social, economic and institutional pressures and opportunities (Figure 2.2).

2.13 Summary of Chapter 2

Future climate change and variability have the potential to have significant and detrimental effects on smallholder farming systems and broader livelihood activities, unless adaptations are undertaken. Adaptation to climate change necessitates consideration of factors that cut across different spatial and temporal scales, policy levels and decision-making contexts. Without a better understanding of past and future local level adaptation and the multi-scalar processes that shape it, whether this be at an local or global level, we run the risk of inappropriate policy prescriptions and adaptations that are ineffective, inefficient and potentially maladaptive (Adger et al., 2003).

This chapter has presented a critical review of a range of literature to provide the contextual background to this thesis. It has identified key research gaps important to advancing understanding of farming systems, adaptive capacity and adaptation in the context of climate change and variability. In particular, this chapter has highlighted the complex and dynamic nature of farming systems and key debates surrounding how farming systems are conceptualised. The literature review highlights a number of case studies that examine farmer responses to climate hazards across SSA (Deressa et al., 2009, Below et al., 2010) and within Uganda (Hisali et al., 2011). This chapter also sets out the conceptual framework (Figure 2.2), how it is applied in this thesis to inform the research design, methodology and data collection process is described in Chapter 3 and Chapter 4.

Chapter 3 Research Design, Methodology and Study Area

3.1 Introduction to Chapter 3

In order to address the gaps presented in the literature review and apply the FSAC framework (Chapter 2), multi-level, multi-methods approaches are needed. This chapter describes the mixed-methods, multi-level research design that informed the case study methodology. Section 3.2 introduces the research design, explains the pragmatic approach adopted in this research and also outlines how systems thinking informed the research design. Section 3.3 outlines the case study methodology. Section 3.4 provides an overview of the climate conditions and trends, agriculture and the policy context in Uganda. Following this, Section 3.5 presents information on selection the study districts and Section 3.6 outlines how study villages were selected. A profile for each of the study villages, is presented in Sections 3.7 and 3.8. Overall, this chapter provides the necessary information to justify the data collection process and methods employed as presented in Chapter 4.

3.2 Research design

Dominant climate change narratives are framed *"exclusively in the language of scientific expertise and physical causation"* (Bravo, 2009:259). Such top-down approaches, also previously termed 'impacts-led' approaches, typically draw on methods used in the natural sciences, such as using computer modelling, to explore, simulate and quantify the impacts of climate changes on agricultural productivity (Twyman et al., 2011). However, evidence presented in the literature review (Chapter 2) demonstrates that farming systems, as well as other SES, will react differently to exposure to similar climate hazards, highlighting the importance of the social, economic and institutional context in shaping how climate change is experienced (Fraser et al., 2011). Additionally, Keating and McCown (2001) argue that there has been insufficient critical evaluation of usefulness of modelling approaches and that there is a need to discover new ways of achieving relevance to real world decisions, such as those related to adaptation planning.

Alternative 'bottom-up' approaches to adaptation planning assess existing vulnerabilities and capacities of systems at different scales; previously referred to as 'vulnerability-led' or 'capacity-based' approaches (Vermeulen et al., 2013). Such approaches, rooted in the social sciences, provide a way of understanding the social, economic and institutional as well as biophysical context. The potential and need to integrate ‘impacts-led’ approaches with ‘capacity-based’ approaches is increasingly recognized (Mastrandrea et al., 2010, Pielke Sr et al., 2007).

Dealing with complex problems such as adaptation, climate change and farming systems requires academic research that moves beyond traditional knowledge boundaries (Tress et al., 2005, Bruce et al., 2004). This thesis used a mixed-methods research design to integrate ‘impacts-led’ and ‘vulnerability-led’ approaches. Mixed-methods, defined here as research which combines research methods, approaches or concepts into a single study (Johnson et al., 2007), involved drawing on quantitative and qualitative elements from the broad areas of natural and social sciences (see Section 3.4). Mixed-methods approaches allow for a wider range of research questions to be asked and enable the rich information generated to present a stronger body of evidence than is possible using a single method (Yin, 2014). For this thesis, exploring adaptation, climate change and smallholder farming systems required consideration of factors interacting across temporal and spatial scales, demanding methods and data from a range of sources and levels.

The multi-level, mixed-methods research was designed to: 1) recognise the importance of using bottom-up, participatory approaches to engage farmers at the local level; 2) enable exploration of linkages between processes across spatial scales; and 3) draw attention to the value of the historical analysis of farming systems and adaptation. This enabled an exploration of the spatial and temporal dynamics of farming systems, climate change and adaptation. It provided insight into the biophysical nature of climate impacts whilst recognising the role of context and farmers’ experiences and knowledge in shaping how future climate change will be experienced (Twyman et al., 2011). This is important given the dynamic, complex and interconnected nature of climate change, adaptation and farming systems.

Despite the advantages of using mixed-methods outlined above, challenges are also present (Fox et al., 2006), not least the reconciliation of underlying philosophies and epistemologies. Underlying philosophies (a system of values that a person adheres to)and epistemologies (understandings of what constitutes knowledge, or what can be known) are important because they influence methodological decisions (Evely et al., 2008).

A wide range of philosophical perspectives underpin social sciences. Positivism represents one of these. Positivism assumes that an objective reality, independent of human behaviour exists. Such reality is concrete and can be objectively studied and measured (Mertens, 2005). Methods obtain estimates of the truth, using data, indicators and estimates that aim to be both unbiased and precise (Evely et al., 2008). Positivism is inherently reductionist and assumes that problems can be narrowly defined and studied (Morgan and Smircich, 1980). However, in the context of climate change, adaptation and farming systems, such narrowly defined problems downplay the importance of human, social and institutional factors in shaping how climate change will be experienced (Rickards et al., 2011).

Some perspectives, such as subjectivism, propose that human experiences, feelings, and values are subjective and therefore influences on behaviour, feelings, perceptions and attitudes are unquantifiable (Evely et al., 2008). Recognition of such subjectivity emphasizes the importance of understanding the processes through which human beings perceive and negotiate their relationships with the world (Morgan and Smircich, 1980). To reconcile some of the potential philosophical and epistemological differences between natural and social sciences, a pragmatic, problem-centred approach was adopted. Pragmatist researchers focus on the 'what' and 'how' of the research problem (Creswell, 2008) and are thus not committed to any particular philosophical perspective or understanding of reality.

For pragmatic researchers, using multiple approaches to answer the research question is central (Johnson et al., 2007); which also justifies the use of a mixed-methods approach in this thesis. Alm and Simon (2001) suggest that pragmatic social scientists might be better able to influence policy than those following other approaches. This stems from the view upheld by many natural scientists who see policy-making, which is subjective, as a separate from science, which is objective.

3.2.1 Systems thinking

The approach to understanding smallholder farming systems, adaptive capacity and adaptation applied in this thesis draws on systems thinking. Systems thinking influenced the research design in three ways, by informing: 1) the conceptual framework of the overall thesis, e.g. systems thinking underpins the FSAC framework (Figure 2.2); 2) the approach to data collection; and 3) the data analysis process, including how data from the multi-level and mixed-methods research design were integrated.

Systems thinking is *“an organised way of tackling messy situations in the real world”* that involves *“logical thought and an ability to see the wood and the trees”* (Checkland, 1999:

1). Structuring problems in this way captures the complexity of reality (Checkland, 1999). Systems approaches have previously been applied to sustainability research, showing promising results in capturing how social, environmental and political factors interact across scales and levels (Dougill et al., 2010). Systems thinking provides a way to analyse complex, dynamic systems and has been applied to SES (Folke, 2006). It also provides a way to understand complexity and dynamics of farming systems (Bammer, 2005). It was therefore deemed an appropriate approach for the multi-level research presented in this thesis. Furthermore, the language around systems thinking applied to SES is often theory-neutral (McGinnis and Ostrom, 2014), and therefore compatible with the pragmatic approach which frames this research.

Analysing the interactions between biophysical and human dimensions of farming systems requires holistic approaches, thus justifying the application of systems thinking in this thesis. For example, systems thinking enables the identification of multiple processes interacting across spatial and temporal scales, from the local to the global level (Ericksen, 2008b). It also provides a way to integrate data from different methods and sources (Dougill et al., 2010). Systems approaches have also been used to connect agricultural research and policy (Collinson, 1987, Darnhofer et al., 2012), demonstrating additional potential for applied benefits.

Systems thinking, which focus on the system level, also has a number of limitations (Duit et al., 2010, McLaughlin and Dietz, 2008). For example, it is criticised for overlooking issues related to power and individual capacities to act (Folke et al., 2005, Smith and Stirling, 2010). This is important because assessments at the system level may mask issues at other, local scales, for example at the household or community level (Cutter et al., 2008). For example, a household may act to strengthen their individual farm system, but at the detriment of an individual's well-being (Coulthard, 2012). This limitation is common to all system-oriented approaches (Leach, 2008), where the focus is on the SES, rather than on the choices made by individuals or groups within the system (Coulthard, 2012). Recognising the capacity of individuals to act is becoming increasingly important to frameworks that analyse SES (McGinnis and Ostrom, 2014). This highlights the need for a better understanding of multi-level interactions that influence individual action. This is addressed in this thesis, which emphasises the role of farmers' experiences, and also uses a case study methodology to explore multi-level interactions between a range of biophysical and human factors.

3.3 Case study methodology

Systems thinking further lends itself to a case study methodology, where a combination of quantitative and qualitative methods are employed and multi-level analyses are undertaken. Case studies are based on intensive and detailed examinations of individual cases (Stake, 1995, Yin, 2009). They are commonly used in research that considers questions of 'what?' 'how?' and 'why?' and are thus compatible with the pragmatic approach used to frame this research. Case studies are particularly useful for generating information at smaller resolutions (Fraser et al., 2006). They also tend to involve a variety of data sources and thus provide a way to integrate bottom up and top down approaches (Jupp, 2006). Additionally, they are well suited for capturing multiple understandings, perceptions and people's agency (Twyman et al., 2011) and therefore represent an appropriate methodology to enhance understanding of farming systems, adaptation and climate change.

A case study methodology enabled an in-depth enquiry and place-based analysis using multiple methods (Chapter 4). It allowed enquiry into how processes across spatial scales shape and produce results in a particular setting (Neuman, 2003) and provided a means to explore issues across different time scales. This resulted in a detailed understanding of farming systems, adaptation and climate change that could not be achieved through any other approach; thus demonstrating its methodological value.

This study focused on Uganda as a case study. The reliability and validity of individual case studies has been criticized, in particular for their limited applicability to inform broader generalisations (Yin, 2009). However, case studies generate rich empirical data., findings are also situated amongst the findings of other case studies from across SSA to enrich the discussion (Chapter 8). Using multiple study sites provide additional insights that could not have been achieved through focus on a single study district. This helped also to ensure that the empirical findings from this research generate insights and lessons that are more widely applicable. More about how reliability and validity are addressed in this study is provided in Section 4.6.

3.4 Case study: Uganda

Uganda is a landlocked country in East Africa lying between 1.0667^{o} N, 31.8833^{o} E (Figure 3.1). It covers around 241,550 km^2, with a land area of approximately 199,807 km^2.

Cultivated land cover increased from 84,010 km^2 in 1990 to 99,018 km^2 in 2005 (UBOS, 2013). The country has a population of around 37.5 million (World Bank, 2014), 24% of which live below the poverty line of less than \$1.25 a day (USAID, 2013). Uganda has a young population with a median age of 15 years and one of the highest annual population growth rates in the world, at 3.2% (CIA, 2014). The country is one of the least developed countries, also referred to as low income or developing countries. Uganda is ranked at 164 out of 187 in the latest Human Development Index (UNDP, 2014).

Figure 3.1 Map showing Uganda, East Africa and the location of major towns in the country (from nationsonline.org)

3.4.1 Climate conditions in Uganda

The climate in Uganda is influenced by a combination of ocean-atmosphere signals, topography and winds, which cause local variations in rainfall and temperature. Uganda has a tropical climate; temperatures vary little throughout the year and are moderated by high altitudes in some locations. Rainfall patterns are linked to the movements of the Inter Tropical Convergence Zone (ITCZ) and El Niño Southern Oscillation (ENSO) (Phillips and McIntyre, 2000). Rain in the southern half of the country tends to follow a bimodal pattern, whereas towards the north and east this merges into one season. This means that climate conditions vary across the country, depending on the geographical area. Current and past trends indicate that the timing of rainfall can vary considerably; the onset of the first rains can shift by 15 to 30 days (earlier or later), while the length of the rainy season can change by 20 to 40 days from year to year (USAID, 2013). Such variations highlight inter-annual variability, which has important implications for agricultural growing seasons (Riddle and Cook, 2008). Osbahr et al. (2011) use climate data to identify years with rainfall and temperatures that exceed inter-annual climate variability. This highlights that climate extremes, such as high temperatures and droughts, are also experienced in Uganda (NEMA, 2009).

Historically, the climate in Uganda demonstrates strong seasonality; the rainy seasons come during the boreal spring (March, April, May (MAM)) and autumn (September, October, November (SON)) (Riddle and Cook, 2008). Factors such as total seasonal rainfall, onsets and lengths of the rainy season and the frequency of occurrence of dry spells influence yields from rain-fed agriculture (Simelton et al., 2013). Seasonal rainfall is particularly important for rain-fed farming systems, where farmers make a range of decisions based on their expectations of rainfall throughout the growing season (Klopper et al., 2006). Seasonal characteristics of rainfall are therefore important (Winsemius et al., 2014, Roudier et al., 2014, Patt et al., 2005).

3.4.2 Climate trends in Uganda

The lack of publicly available climate data in Uganda has resulted in a lack of peer reviewed studies at the country level (Osbahr et al., 2011). The limited academic and grey literature on past and future climate trends for both East Africa and Uganda (including information provided in national policies) was nevertheless reviewed.

Earlier regional analyses, including the IPCC report published in 2007, suggested that rainfall would increase in East Africa (Christensen et al., 2007, IPCC, 2007). In the IPCC's Fifth Assessment Report, Niang et al. (2014) project likely increases in mean annual precipitation over areas of East Africa, and a wetter climate with more intense wet seasons and less severe droughts during October, November, and December (OND) and March , April, and May (MAM). These results indicate a reversal of historical drying trend in these months (Niang et al., 2014). However, other studies contradict this. For example, recent regional projections suggest drying over most parts of Uganda, and that annual rainfall is due to decline further (Funk et al., 2012). Other projections highlight that during 2041-2060 rainfall in SON will increase in Uganda, resulting in a longer growing period (Cook and Vizy, 2012). Regional studies highlight that the global models suppress important local mechanisms (for example, orographic gravity waves) and overlook the complex terrain that also influences the climate in Uganda (Funk et al., 2008). Uncertainties highlight a lack of scientific consensus about future rainfall trends for Uganda.

According to climate analysis presented in Uganda's NAPA, the wetter areas, for example around the Lake Victoria basin and the east and northwest, are becoming wetter, while in the drier regions in western, northern and north-eastern areas, droughts are becoming more frequent (RoU, 2007). The NAPA states that it is likely that there will be an increase in the number and strength of extreme weather events, such as droughts, floods and storms across Uganda (RoU, 2007). Existing studies assess the impacts of climate extremes on agriculture in Uganda (Bashaasha et al., 2012) and have analysed how households cope with such rainfall and temperature extremes (Berman et al., 2014). Less is known about how households respond to other types of climate hazards, such as incremental changes in climate trends and climate variability, thus justifying the need for parts of this thesis to focus on climate hazards (Chapter 6). Rainfall is the defining factor of seasonality in Uganda (Herrmann and Mohr, 2011), however, the literature also highlights a gap in understanding of how farmers adapt to incremental changes in rainfall trends, therefore part of this thesis also focuses on projections of, and adaptation to, future rainfall projections trends for the 2030s (Chapter 7).

Some studies show that spring and summer rains in Uganda decreased between 1990-2012 compared with a 1960-89 baseline (Funk et al., 2012) and that annual rainfall has decreased by 3.4 mm per decade (McSweeney et al., 2008, McSweeney et al., 2010). However, other analysis shows no significant change in average annual rainfall in the 60-year historical record (comparing 1951-1980 and 1981-2010) (USAID, 2013). Seasonal rainfall totals during MAM have been declining in East Africa since 1980, reducing the length of the growing season (Cook and Vizy, 2013); these trends are set to continue (Funk et al., 2012, Funk et al., 2008).

There are some similarities and differences between 2030s' projections in McSweeney et al. (2008), United States Agency for International Development (USAID, 2013), and IPCC (2013b). McSweeney et al. (2008) project changes in annual rainfall of between -7% and +14% for Uganda in 2030s compared with observed mean rainfall from 1970-99. USAID project no significant change in average annual rainfall for the 2015-2045 period, but much larger changes in inter-annual variability (USAID, 2013). Country-level analyses provided by McSweeney et al. (2008) are based on climate observations and the multi-model projections made available through the World Climate Research Programme's (WCRP's) Coupled Model Inter-comparison Project phase 3 CMIP3 multi-model dataset referenced in the Intergovernmental Panel on Climate Change Fourth Assessment Report (McSweeney et al., 2010). Both USAID (2013) and the IPCC Fifth Assessment, which were released after fieldwork, are based on Coupled Model Inter-comparison Project phase 5 (CMIP5) multi-model dataset (for more information see Taylor et al., 2011).

The Africa Climate Change Resilience Alliance (ACCRA, 2011) provide an overview of national climate trends for Uganda for the 2060s and 2090s. These projections are based on the Providing Regional Climates for Impacts Studies (PRECIS) climate model, but data are derived from the Department of Meteorology in Uganda and sourced from unpublished site reports (ACCRA, 2011). Findings from ACCRA project overall increases in the proportion of rainfall that falls in 'heavy' events (i.e. with greater intensity) and that projected increases in rainfall are most extreme in the short rainy season (ACCRA, 2011). Although it is unclear how rainfall patterns have changed and what can be expected in the future (consistent with General Circulation Model (GCM) predictions for East Africa), rainfall variability has increased (Christensen, et al., 2007). The uncertainties about future climate trends in Uganda make it important for this thesis to consider a range of plausible future 2030s' climate projections, rather than selecting specific projections.

Analysis of temperature trends in Uganda conducted by McSweeney et al. (2010) shows that mean annual temperatures have also already increased by 1.3˚C since 1960, at an average rate of 0.28˚C per decade, yet in January and February this rate stands at 0.37˚C per decade. This is consistent with other analyses of past temperature trends in Uganda (Bashaasha et al., 2012, Mubiru et al., 2012, RoU, 2007). Projections suggest that annual temperatures will increase by between 0.5 ˚C and 1.7 ˚C by the 2030s depending on the

SRES (A2, A1B, B1). Changes in monthly totals for the 2030s are between 0.3 ˚C and 2.1 ˚C, again depending on the SRES (A2, A1B or B1) and the time of year. Increases in temperature can affect agriculture in a number of ways, for example it directly influences soil moisture availability, and therefore influences crop development. It can also have an indirect influence on crop development, including on pests and diseases.

3.4.3 Agriculture in Uganda

Growth in agricultural output has declined, from growth rates of 7.9% in 2000/01 to 0.7% in 2007/08 (MAAIF, 2010a). In 2012/13 the sector grew by 1.5%, nearly double the 0.8% growth rate recorded the previous year (MoFPED, 2013). However, in 2012/13 the contribution of the agricultural sector to GDP declined from 23.8% to 22.9% (MoFPED, 2013). At the macro level, the agricultural sector in Uganda faces a number of challenges, for example: declining soil fertility; high losses due to pests and diseases; inadequate infrastructure; low levels of value addition; poor quality public investment; and multiple policy frameworks that create a confusing institutional environment for investment (MAAIF, 2010a). In addition to this, climate changes are set to pose an additional risk to agricultural productivity (Mubiru et al., 2012). Given the lack of publicly available data, it is difficult to compare agricultural outputs and production trends with the weather conditions experienced in relevant years.

Around 66% of Uganda's working population is engaged in the agricultural sector and directly depend on agriculture as a major source of livelihood (UBOS, 2013). The systems that underpin the agricultural sector are predominantly smallholder farming systems. In order to reflect the nature of farming in Uganda, this research focussed on smallholder farming systems, where farming is predominantly undertaken for subsistence purposes.

Figure 3.2 highlights that Uganda comprises a range of agro-ecological zones and ecosystems (RoU, 2007), which also influence the nature of farming systems. In 2004, a Taskforce created by the Republic of Uganda (RoU), used agro-ecological information in conjunction with other climatic, socio-economic, agricultural, and cultural data to demarcate the country into Agricultural Production Zones (APZs); each with different production features (RoU, 2004). Uganda is currently divided into 10 APZs (MAAIF, 2010a). The Ministry of Agriculture, Animal Industry and Fisheries (MAAIF) has identified profitable agricultural enterprises for each APZ where they have the best comparative advantage according to the agro-ecological zone, farmer resource endowments and market opportunities (MAAIF, 2010a). Commodities that are best suited for each zone receive government support, for example agricultural subsidies and extension services (MAAIF, 2010a). Such agro-ecological zoning also demonstrates that sub-national differences in farming systems within Uganda are important.

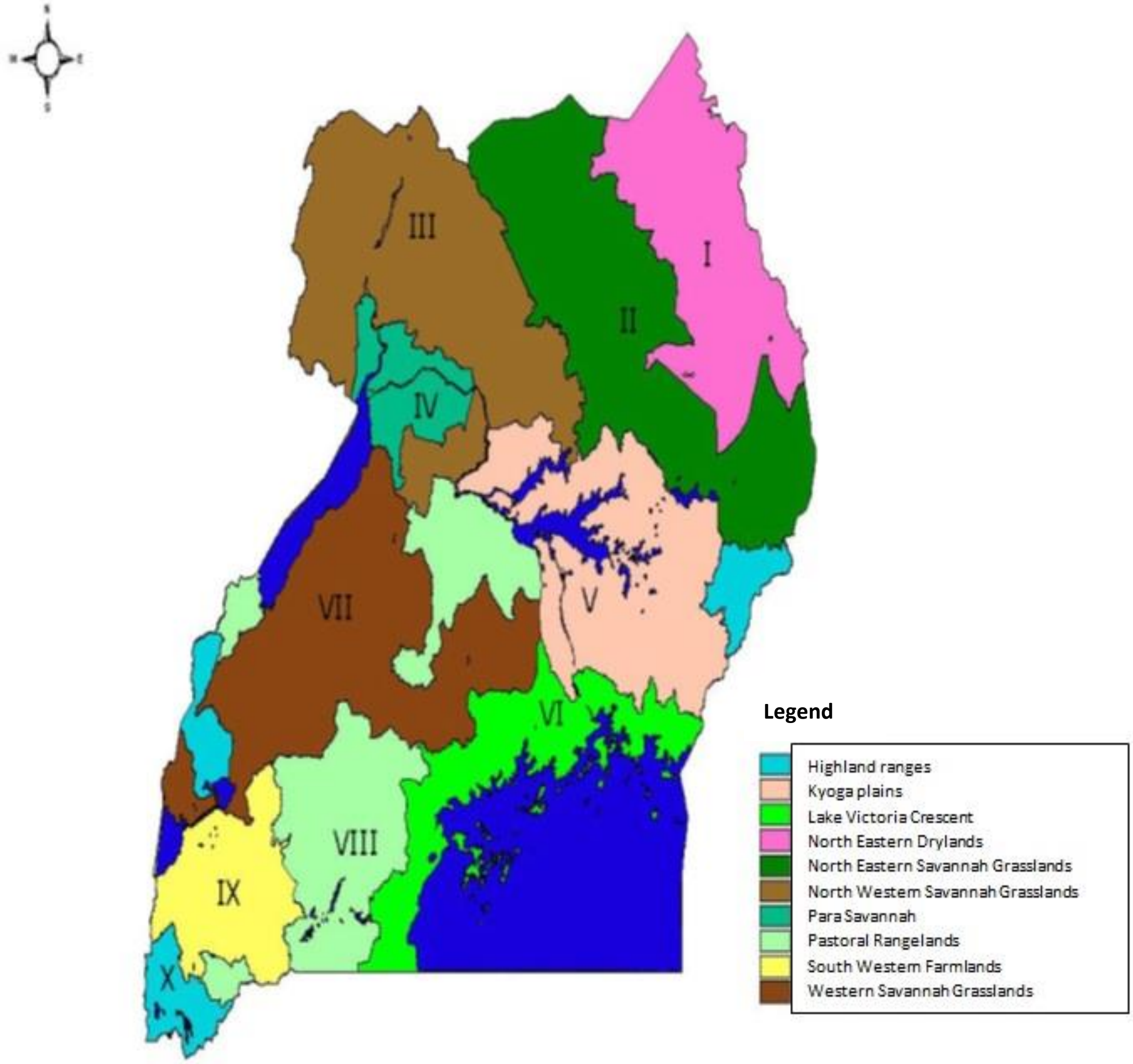


Figure 3.2 Map showing agro-ecological zones in Uganda (RoU, 2004)

3.4.4 Policy context

International and regional level policies can influence national level policies. In Uganda, for example, Comprehensive Africa Agriculture Development Programme (CAADP) is a regional initiative of New Partnership for Africa's Development (NEPAD) that requires member countries to allocate 10% of the national budget to the agricultural sector. Although this thesis recognises the importance of such agreements in influencing policy, focus is placed on national level agriculture and adaptation policies. Uganda has multiple national agricultural policies, including both short term plans (less than five years) and longer term strategies. Although the country has decentralized governance structures, these are still guided by overarching national policies. Policies are therefore broadly defined as formal, governmental policies, including frameworks, strategies and plans.

The NAPA (RoU, 2007) is the only current relevant policy in Uganda that focuses explicitly on climate change and adaptation and cuts across other sectors. It documents existing coping strategies, and identifies potential adaptation interventions. Adaptation interventions are identified, ranked and prioritised through a multi-step, participatory process, involving a range of stakeholders, including local communities from across Uganda. The final list of adaptation intervention priorities is guided by national development goals and also in accordance with the immediacy, urgency and magnitude of the problem as judged by the NAPA.

The National Development Plan (NDP) provides the overarching framework to guide development priorities and implementation strategies (RoU, 2010). Within this framework, various agencies and policies have been developed to guide investment priorities for specific sectors. Whilst the National Agricultural Policy (NAP) is the current overarching policy for all agriculture related policies (MAAIF, 2011), the Agriculture Sector Development Strategy and Investment Plan (ASDSIP) is the medium term policy that provides detailed plans for the implementation of priorities outlined in the NDP (MAAIF, 2010b). The National Agricultural Advisory Services (NAADS) programme was created in 2001 to transform subsistence agriculture into market-oriented agriculture for commercial production and therefore focuses on delivery of extension services and input subsidies (NAADS, 2014). It is a donor-funded programme established in 2001 by an Act of Parliament. It is one of the seven pillars of the Plan for the Modernization of Agriculture and formed part of the Poverty Eradication Action Plan (MoFPED, 2004), which was replaced by the NDP in 2010 (RoU, 2010).

Although these are national level policies, Uganda has adopted decentralisation as a mechanism to promote public participation and good governance, enhance service delivery, and promote sustainable natural resource management (Capon and Lind, 2000). This demonstrates a need for a multi-level analysis in order to understand the policy context in Uganda.

3.4.5 Decentralisation in Uganda

Decentralisation in Uganda is formalised in the legislative framework provided by the Local Governments' Statute of 1993, which initially facilitated administrative and financial decentralisation. Article II of the Constitution of Uganda (1995) set out support for decentralisation and formalised the role of local government in principle (RoU, 1995). The Local Government Act 1997 and later amendments subsequently enabled the consolidation and implementation of decentralisation, which included powers for districts to generate local revenue through taxes and the ability to govern the distribution of generated revenue autonomously (RoU, 1997).

Local governance systems are important for understanding decision-making processes and the policy context in Uganda (Van Alstine et al., 2014). The system of local government in Uganda is based on the district as an administrative unit. Currently, there are 111 administrative districts, linked to district level local government and administrative unit councils. Tiers of local government and administrative unit councils are linked through complex political and administrative arrangements (Saxena et al., 2010). Each unit has various political, administrative, planning, budgeting, financial, legal and institutional powers (Onyach-Olaa, 2003). Rural areas are divided into districts, counties, sub-counties, parishes and villages. Urban areas are composed of municipalities and towns, which are further split into divisions, wards or parishes, and villages or zones (Steffensen et al., 2004).

This research focuses on rural farming systems, and therefore considers the governance structures designed for rural areas. In rural areas, local governments are split into two tiers. The district forms the highest level of local government and the sub-county is the lowest (RoU, 1997). Both tiers of local government have legislative and executive powers, meaning that they make policy decisions, formulate laws and raise revenue, in addition to being responsible for service delivery, policy implementation and law enforcement (RoU, 1997). Therefore both levels of local government were considered in this research. Although counties, parishes and villages play an important role in monitoring service delivery and maintaining law and order, they are political units that advise rather than having legislative and executive powers (MoLG, 2014), hence were not focused upon. This multi-level governance system highlights the relevance of conducting multi-level research as described in Section 3.2.

Local governance systems are embedded within the national governance framework. For example, relevant line ministries for each sector carry out technical supervision, technical advice, mentoring of local governments and liaise with international agencies. In addition to this, sub-counties, which are the lowest level of local government, are directly involved with service delivery at a village level. This highlights the importance of conducting multi-level analysis to understand the linkages between policy and practice. Such multi-level governance structures also suggest that adaptation planning should be targeted at multiple levels.

3.5 Selecting study districts

The diversity of cultures, people, climate and environment makes it impossible to make generalisations about farming systems at a national scale in Uganda. Two administrative districts were selected to represent two distinct farming systems (NEMA, 2009). Within these study districts, stakeholders from both tiers of local government (district and sub-county) were included.

Both of the selected districts, Soroti District and Jinja District, are found in the eastern region of Uganda. The eastern region was identified as a particular area of interest because of the heterogeneity of farming systems within the same geographical area. Characteristics of the two study Districts will be outlined in this section and reflected on throughout this thesis.

Soroti District lies in the Teso sub-region and Jinja District in the Busoga sub-region, which evolved from traditional kingdoms or chiefdoms, meaning that there are some cohesive characteristics that unite the people in a particular geographical location. This resulted in in socio-cultural, historical and language differences between the study Districts. Soroti District is located in the 'Southern and Eastern Lake Kyoga Basin' AEZ (Figure 3.2), has annual rainfall of between 1,200 mm and 1,450 mm per annum and experiences two rainy seasons and a distinct dry spell from November-February (NEMA, 2009, SDLG, 2011). Jinja District is part of the 'Lake Victoria Basin and Mbale Farmlands' AEZ. It has higher annual rainfall of between 1250 mm and 2000 mm (NEMA, 2009) and experiences two rainy seasons, though the timings, duration and distribution are different to those of Soroti District. Traditionally, maize, beans, sweet potatoes, coffee and bananas are the main crops grown in Jinja District, whereas millet, cotton, and other annual crops such as sorghum are cultivated in Soroti District. This demonstrates that different farming systems are also found in Jinja District and Soroti District. This thesis therefore distinguishes between the Jinja Farming System (JFS) and the Soroti Farming System (SFS). More geographical, environmental and climatic information about Jinja District and Soroti District is summarised in Table 3.1.

Table 3.1 Summary of climate and agricultural data and village level information for Jinja District and Soroti District.

	Jinja District	**Soroti District**	**Source of Information**
Sub-region	Busoga	Teso	(SDLG, 2011, JDLG, 2011)
Main ethnic groups	Basoga	Iteso, Kumam	(SDLG, 2011, JDLG, 2011)
Bordering Districts	Kamuli (N), Luuka (E), Buvuma (S),Buikwe (W)	Serere (E), Ngora (S), Katakwi (W), Amuria (N)	(SDLG, 2011, JDLG, 2011)
Agro-climatic zone	Sub-humid	Semi-arid	(Tenywa et al., 2005)
Agro-ecological zone	Lake Victoria Basin and Mbale Farmlands	Southern and Eastern Lake Kyoga Basin	(NEMA, 2009)
Agricultural Production Zone	Lake Victoria Crescent	Kyoga Plains	(MAAIF, 2010b)
Major Crops	Maize, beans, sweet potatoes, coffee and bananas.	Banana, cotton, cattle and annual crops, e.g. sorghum and millet.	(NEMA, 2009)
Vegetation	Some forest/savannah, but modified by urbanisation, industrial, commercial and residential activities.	Wooded and grass savannah.	(SDLG, 2011, JDLG, 2011)
Annual Rainfall range	1250 mm – 2000 mm	1,200 mm – 1,450 mm	(NEMA, 2009)
Rainfall Seasons	Bimodal: March – May, September – December Low rainfall: December-March and June-July	Bimodal: March–June, August – November Dry Spells: November to March	(SDLG, 2011, JDLG, 2011, NEMA, 2009)
Strategic Enterprises (2010 – 2015)	Dairy Cattle, Fish, Coffee, Poultry	Poultry, Cassava, Pineapples, Citrus	(MAAIF, 2010b)

3.6 Selecting study villages

Data were collected in four villages in each district to represent two different agro-ecological zones and farming systems. Villages were purposefully selected within each district to represent a range of different sized villages. Geographic criteria were used to represent the district in terms of the main livelihood activities, environment and social conditions, and distance to an urban centre/main road. These criteria are established in the literature as important in influencing the nature of rural farming systems (Dixon et al., 2001). Using such criteria also ensured that the diversity within each study district was captured in terms of environmental and socioeconomic conditions, providing valuable context for the in-depth, multi-level analysis.

With these criteria, several villages in both districts were eligible to be included in the research. Key informants working in local government, for example agricultural extension officers, provided additional documents (e.g. census information) and advice to inform the village selection process. Villages were selected: a) to represent a range of different sized villages; b) to represent the main livelihood activities; c) to represent the social and environmental conditions of the district; d) if they were accessible by road; and e) if relevant permissions could be gained and people were willing to participate in the study.

3.7 Soroti District: Village profiles

The four villages selected in Soroti District are located in either Katine sub-county or Arapai sub-county. Contextual information about each of the study villages is provided in Table 3.2. Similarities are apparent in terms of available water sources, environmental features, housing, access to electricity, type of markets, household sanitation practices, availability of primary education, and presence of government programmes. Differences relate to the number of households per village, the distance to Soroti Town, distance to a tarmac road, local availability of healthcare, ethnic groups, and NGOs operating in the area. The differences in terms of roads, accessibility and distance from town are not surprising given that location was one of the selection criteria. Although people are dependent on agriculture as the main source of livelihood, the combination of livelihood activities being pursued to provide income at a household level varied both between the villages and between households within the same village.

Table 3.2 Village profiles compiled from primary data collected through interviews, focus groups and observations for each study village in Soroti District

	Agirigiroi Village	**Adamasiko Village**	**Kangeta Village**	**Merok Village**
Sub-county	Arapai	Katine	Arapai	Katine
No of households	~700*	113	347	106
Distance to Soroti Town	31 km	12km	8km	25km
Ethnic Groups	Iteso (100%) Kumam (0%)	Iteso (95%) Kumam (5%)	Iteso (60%) Kumam (40%)	Iteso (11%) Kumam (89%)
Water Sources	6 boreholes, some seasonal springs, shallow wells and swamps	1 borehole, few seasonal swamps/springs	3 boreholes few seasonal swamps/springs	3 boreholes few seasonal swamps/springs
Irrigation	1 farmer with irrigation system (not operational)	None	None	None
Environment Features	Grasslands with small shrubs/trees, few big trees	Grasslands with small shrubs and Borassus palm trees	Grasslands with small shrubs, few big trees	Grasslands with small shrubs/trees, few big trees
Land	Customary land tenure Cultivated land and uncultivated land Some communal land for grazing animals	Customary land tenure Mostly cultivated land Some communal land	Customary land tenure Mostly cultivated land Some communal land	Customary land tenure Cultivated land and uncultivated land Some communal land
Housing	Predominantly grass thatched	Predominantly grass thatched	Predominantly grass thatched	Predominantly grass thatched

	Agirigiroi Village	Adamasiko Village	Kangeta Village	Merok Village
Roads	Poor feeder road network, only 1 graded road 18 km to tarmac road (Soroti /Lira)	Basic feeder road network, multiple graded roads recently maintained 7km to tarmac road (Soroti/Moroto)	Basic feeder road network, multiple graded roads recently maintained 3km to tarmac road (Soroti/Moroto)	Poor feeder road network, no graded roads 3km to tarmac road (Soroti /Lira)
Markets	2 local trading centres and Tubur Market	Markets in Arapai and Soroti Town Few local markets in neighbouring trading centres	Markets in Arapai and Soroti Town	Market in Katine
Healthcare	Health centre	No health centre (2 km from nearest)	Health centre at Arapai sub-county	No health centre (10km from nearest)
Sanitation	Pit latrines in most households	Pit latrines in most households	Pit latrines in most households	Pit latrines in most households
Electricity	No electricity, few households with solar panels	No electricity, few households with solar panels	No electricity, few households with solar panels	No electricity, few households with solar panels
Education	2 primary schools	1 primary school	2 primary schools	1 primary school
Government programmes	NAADS, NARO, NUSAF	NAADS	NAADS, NUSAF	NUSAF, NAADS
NGOs/CSOs	Local and international NGOS, e.g. World Vision (ended in Dec 2012)	Local and international NGOS, e.g. CIDI, Danida, AMREF (ended 2012)	Local and international NGOS, e.g. CIDI, CCF (ended in 2012), World Vision (ended Dec 2012)	Local and international NGOS, e.g. AMREF, CCF
*Plans for Agirigiroi Village to become a Parish made up of 6 villages (Okunguro, Abata, Asiki, Akusi, Abilangit, Amorordek) in next election; dates yet to be confirmed				

3.8 Jinja District: Village profiles

The four villages selected for this study in Jinja District are located in the administrative sub-counties of Buwenge or Butagaya. Contextual information about each village is provided in Table 3.3. Similarities are apparent between the villages in terms of ethnic groups, water sources, land, irrigation, housing, markets, healthcare and presence of government programmes. Differences relate to the number of households per village, the distance to a town centre (either Jinja or Buwenge), and presence or absence of NGOs operating in the area. As with the villages in Soroti District, all respondents were dependent on agriculture as their main source of livelihood. However, the combination of livelihood activities being pursued to provide income at a household level varied between the villages, and between households within the same village.

Table 3.3 Village profiles compiled from primary data collected through interviews, focus groups and observations for each village in Jinja District

	Bukolokoti	**Bituli**	**Idoome**	**Kalugu**
Sub-county	Buwenge	Butagaya	Buwenge	Butagaya
No of households	~100	~120	~320	~100
Distance to Buwenge Town	4km	11km	6km	16km
Distance to Jinja Town	37km	30km	35km	35km
Ethnic Groups	Basoga	Basoga	Basoga	Basoga
Water Sources	4 boreholes, some seasonal springs and swamps	boreholes (Unknown number)	3 boreholes	1 borehole, 2 shallow wells and seasonal swamps
Irrigation	None	None	None	None
Environment Features	Many/large-scale sugarcane plantations, pine forest and some old trees	Few sugarcane plantations, some pine forest and some old trees	Many/large-scale sugarcane plantations, village surrounded by swamps, some old trees	Close to banks of river Nile, pine tree forest, few sugarcane plantations Village surrounded by swamps to the north, few old trees
Land	Predominantly cultivated land, individual/household plots	Predominantly cultivated land, individual/household plots	Predominantly cultivated land, individual/household plots	Predominantly cultivated land, individual /household plots
Housing	Majority permanent houses	Majority permanent houses	Majority permanent houses	Majority permanent houses

	Bukolokoti	**Bituli**	**Idoome**	**Kalugu**
Roads	Poor feeder road network	Poor feeder road network, but major graded road runs through village	Poor feeder road network, one graded road. Road impassable in rain	Poor feeder road network, one graded road
Markets	Sell from home (‘Middlemen’) Few take to Buwenge Town	Sell from home (‘Middlemen’) Few take to local markets	Sell from home (‘Middlemen’) Few take to Buwenge Town	Sell from home (‘Middlemen’) Few take to local markets
Healthcare	No Health Centre	No Health Centre	No Health Centre	Health Centre (not yet opened)
Sanitation	Pit latrines	Pit latrines	Pit latrines	Pit latrines
Electricity	No electricity	Main line electricity (since 1990s), but household access remains low	No electricity	No electricity, few households with solar power
Education	No School	1 Primary School	2 Primary Schools	No School
Government programmes	NAADS	NAADS	NAADS	NAADS
NGOs/CSOs	No data	A few local NGOs	A few local NGOs including farmers/livestock groups	A few local NGOs
Irrigation	None	None	None	None

3.9 Summary of Chapter 3

This chapter has set out the theoretical grounding for the research design, the case study methodology and pragmatic approach adopted by this research. It has also presented multi-level, mixed-methods approach that informed methodological decisions. Relevant contextual background information about Uganda is also highlighted and the process of selecting two study districts and the four study villages within each district is outlined. Finally, the chapter has summarised some of the characteristics of the study districts and the study villages in which empirical data collection was undertaken. More about the data collection process and methods is provided in Chapter 4.

Chapter 4 Data Collection and Methods

4.1 Introduction

Informed by the literature review (Chapter 2), this thesis will draw upon a range of methods, including participatory methods, to engage a range of relevant stakeholders. This will facilitate a better understanding of the complex dynamics of farming systems, adaptive capacity and adaptation that operate and interact over space and time. This chapter provides a detailed description of the data collection process and the methods used to generate data for each of the research objectives. Section 4.2 describes how the FSAC framework (Figure 2.2) was applied and Section 4.3 summarises data collection process and methods. This includes an overview of fieldwork in Uganda and details about the methods that were used, including a summary of how secondary data analysis was undertaken. Section 4.4 describes how primary data were analysed and integrated to address the research objectives. Section 4.5 details information about researcher positionality and other ethical considerations. These are outlined to provide important information about the way in which this study was conducted. Section 4.6 reflects on issues of validity before Section 4.7 summarises the chapter. Although the majority of the information about the methods and analysis is provided in this chapter, a synthesis of how methods and analysis were used to achieve each research objective is presented in the methods section of each individual results chapter as well.

4.2 Applying the farming systems adaptive capacity framework

This section outlines how the FSAC framework (Figure 2.2) was applied in this chapter, then continues to outline how it informed the rest of the thesis. ,

The FSAC framework informed selection of methods and the data collection process, as presented in this chapter. It shaped the types of questions asked in household surveys and topics for conversation during the semi-structured interviews. A summary of this is presented in Figure 4.1 to show how the methods used are linked and provide coverage across the different aspects of the framework. More details about these methods are presented in Section 4.3.

The FSAC framework was further applied throughout this thesis to organise and integrate primary quantitative and qualitative data with secondary data (Section 4.4). In Chapter 5 the FSAC framework provides a basis for analysing the evolution of farming systems and adaptive capacity. In Chapter 8, the FSAC framework is drawn upon to synthesise data from across the results chapters and to summarise the empirical contribution of this thesis. Applying the framework like this provided a way to explore interconnectedness between the framework components and to think holistically about the interacting components, adaptation and non-linear behaviour found in farming systems (Matthews and Selman, 2006). This generated insights into the interconnectedness and interdependence of the components of a farming system which operate at and across points of time and space. It also enabled links between the biophysical production systems and the management system (or system of farming) to be explored (Keating and McCown, 2001).

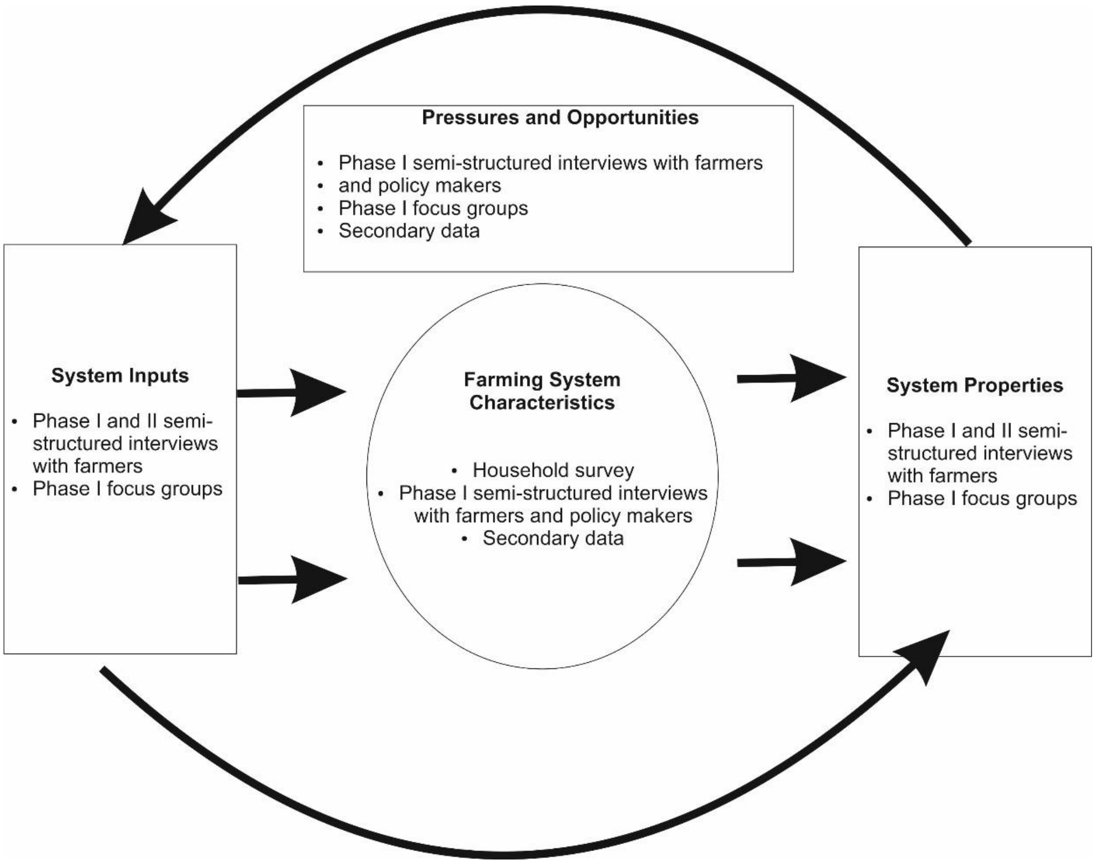


Figure 4.1 Overview of how methods cover all components of the farming system adaptive capacity framework (adapted Figure 2.2).

Finally, the FSAC was also used in the analysis stage for each results chapter as a useful way to distinguish between different units of analysis. In Chapter 5 it enabled farm households with similar characteristics and constraints to be grouped together to enable analysis of a farming system. Across the results chapters, it enabled a conceptual distinction to be made between farming systems, individual farm systems, farm systems and farm households. Applied in this way, the FSAC framework provided a practical tool to guide the multi-level analysis of farming systems, adaptation and climate change required in this thesis.

4.3 Data collection and methods

Primary data were collected in the administrative districts of Soroti and Jinja using a range of quantitative and qualitative methods including: observations, semi-structured interviews, focus groups, household surveys and policy analysis. Quantitative data provided an overview of the study villages which was essential to identify a number of past, present and future issues associated with farming systems and adaptation. Qualitative data explored the evolution of farming systems (Objective 1), and household responses to climate hazards (Objective 2). A combination of quantitative and qualitative data were used to elicit responses about autonomous agricultural adaptations to 2030s' rainfall projections (Objective 3).

For each research objective, data were collected from different sources at different levels and points in time (Figure 4.2). Using a variety of methods allowed understanding of different dimensions of the issues that could not have been gained from using a single method. Primary data were captured using recording sheets, notebooks, a digital recorder and digital camera. All recording sheets were also input digitally to ensure that data were backed up. All digital data were stored on a password protected computer. Primary data were also verified during January 2013, more about this process is provided in Section 4.3.7.6.

4.3.1 Fieldwork in Uganda

Fieldwork to collect primary data was split into three interlinked phases. This section provides an overview of each phase, the methods used and how they link with the research objectives. Table 4.1 provides a summary of the methods used during fieldwork.

Phase I of data collection took place between January and May 2012. These months were selected to capture a full growing season, from preparing land in January to harvesting in May. Phase I focussed on past and present issues from 1960 – 2012 related to smallholder farming systems, adaptation and climate change. 1960 – 2012 was selected as the time frame for enquiry in order to match people's ability to remember, and forms the baseline period for climate projections in Uganda (McSweeney et al., 2008). It also follows on from when Uganda gained independence in 1962. A range of methods was used during Phase I to generate specific data to contribute to research objectives 1 and 2 (Figure 4.2). Additionally, Phase I provided contextual information about the study villages.

The second phase of fieldwork lasted from June until September 2012 and focussed on exploring adaptation to projected rainfall scenarios and policy recommendations. Phase II involved semi-structured interviews with farmers linking 2030s' rainfall projections with participatory methods (rainfall calendars and seasonal calendars) (Table 4.1). Developing 2030s' rainfall projections involved analysis of secondary rainfall data provided by McSweeney et al. (2008). During Phase II, semi-structured interviews with government and non-government actors working at the subnational level were also undertaken to discuss decision-making processes and policy implementation.

Table 4.1 Summary of the methods used, and sampling strategy for data collected in each study village during fieldwork (Phases I-III). Data compiled from semi-structured interviews (SSIs), focus group discussions (FGDs), and household surveys (HHS).

Jinja District							
Phase	**Method**	**Sampling**	**Bituli**	**Bukolokoti**	**Idoome**	**Kalugu**	**Total**
Phase I (January and May 2012)	Semi-structured interviews with farmers	Snowball	4	5	4	5	18
	FGDs with farmers	Cluster	1	2 *	2	2 *	7
	HHS - questionnaire	Random	0	0	0	0	0
Phase II (June and September 2012)	SSIs with local government stakeholders	Snowball	..	..	..	..	6
	SSIs with non-governmental stakeholders	Snowball	..	..	..	..	3
	SSIs with farmers	Purposive	2	2	2	1	7
Phase III (January 2013)	Follow-up FGDs	Cluster	1	1	1	1	4
Soroti District							
Phase	**Method**	**Sampling**	**Adamasiko**	**Agirigiroi**	**Kangeta**	**Merok**	**Total**
Phase I (January and May 2012)	Semi-structured interviews with farmers	Snowball	8	8	3	7	26
	FGDs with farmers	Cluster	2 *	2	2	2 *	8
	HHS - questionnaire	Random	98	99	90	100	387
Phase II (June and September 2012)	SSIs with local government stakeholders	Snowball	..	..	..	..	4
	SSIs with non-governmental stakeholders	Snowball	..	..	..	..	4
	SSIs with farmers	Purposive	2	2	3	3	10
Phase III (January 2013)	Follow-up FGDs	Cluster	1	1	1	1	4
*Indicates female only FGD							

Primary data collected in Phase I and Phase II were verified during the third phase of fieldwork in January 2013. Follow-up focus groups were held in each study village to report back preliminary research findings, triangulate findings from different methods and provide an opportunity for questions and clarifications on both sides. Eight FGDs were conducted across the study districts with representatives from each village. More about these FGDs is provided in Section 4.3.7.6.

Phase III also involved identifying and analysing the content of three national policies, specifically; agriculture, development and adaptation policies (Section 4.3.9.1). This process was designed to assess the relationship between planned and autonomous adaptation (Objective 3).

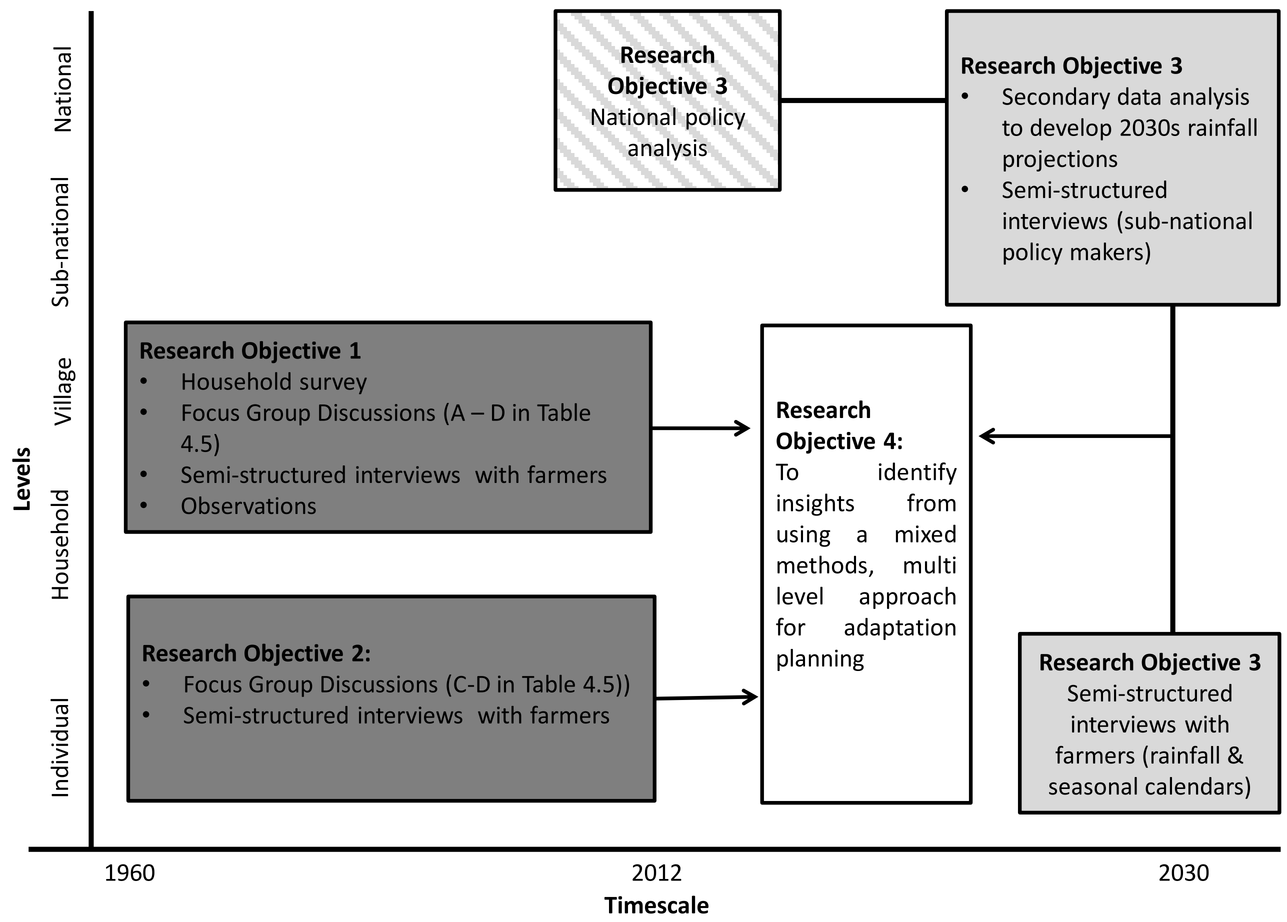


Figure 4.2 Overview of research methods linked to research objectives demonstrating how different data were collected at different levels and points in time. Methods used during Phase I of fieldwork are highlighted in dark grey boxes, those used during Phase II are shaded in light grey, and Phase III have a patterned fill..

An overview of the methods used in this thesis is provided in Table 4.2. Different methods were used at different levels (Table 4.3). Semi-structured interviews were conducted at the household, village, sub-county and district level. FGDs were conducted at the village and district level, whereas the HHS was undertaken only at the village level. At the village and household level, participatory methods were used during both FGDs and semi-structured interviews as an alternative to structured interviews and quantitative social surveys. The same methods were used across all villages in both districts to capture past and present issues as well as future concerns. This combination of methods enabled triangulation of research findings. More information about how each method was used in this research is provided under each relevant sub-heading in this section; this structure is used to ensure clarity and consistency across the methods section.

Table 4.2 Overview and evaluation of research methods, compiled using (Brockington and Sullivan, 2003, Creswell, 2008, Matthews and Selman, 2006, Neuman, 2003)

Method	Description	Strengths	Potential Challenges	Solutions
Observations	Taking part in everyday household activities and community events	Involves working closely with people in their natural setting Makes it possible explore perspectives and gain meaningful insight into participants livelihoods.	Time – to build trust and relationships Language as a potential barrier to full participation – rely on translator Knowledge and information obtained may be affected by the presence of the researcher. Subjectivity of the researcher - bias	Choose a manageable number of research sites allowing for enough time to develop relationships. Recruit and induct a research assistant who is familiar with the local languages and setting. Use an observational protocol. Combine and triangulate with other sources of data
Focus Groups	Group discussions of livelihoods, environmental change and adaptation. Used focus groups as a format for participatory methods.	Useful tool to stimulate discussions, which adds depth to data. Interesting to observe interactions noting who is speaking as much as what they are saying. Opportunity for groups to engage with a topic- dialogue, rather than one way communication.	Logistically challenging Need to spend sufficient time with a group to interpret group dynamics. Knowledge and information obtained may be affected by the presence of the researcher. Language as a potential barrier to full participation – rely on translator Group dynamics – powerful members dominating	Select an appropriate time, place Use a translator / research assistant to record data. Use an observational protocol. Have at least 1 introductory meeting and try to build relationships. Use facilitation skills to manage group dynamics – be clear that it is an open process and there are no wrong answers

Participatory Methods (including causal diagrams, ranking, and problem trees)	Techniques used to engage participants – an explicit alternative to large scale surveys. Can be used to inform sampling techniques.	Challenge the dominance and power of the researcher to give more prominence to the voice of researched people. Participants can explain and discuss their ideas Doesn't require literacy	Knowledge and information obtained may be affected by the presence of the researcher. Need to understand relevant social, cultural and political context to understand knowledge produced.	Researcher has understanding of social, cultural and political context. Issues will be discussed with a research assistant. Contextualised and triangulated with other methods.
Semi-structured interviews	Allow for discussions on a particular list of topics – open ended questions on mainly climate change and related policies and institutions	Follow up on issues Allow participants, maybe not comfortable in group settings and build relationships with individuals Useful way to triangulate data	Researcher bias Potentially not a natural setting Recording the data can be problematic as writing while people are speaking is off putting. Recoding the data in later analysis stages can be difficult.	Be reflective, discuss issues with a translator and analyse critically Do it a natural setting for the participant, i.e. office Ask permission to record interviews Think about coding and structure during fieldwork
Field Diary	A day to day record of observations, thoughts and reflections	A useful way of keeping track of events, context and settings. Can jog memory and add additional insight	Difficult to write a comprehensive fieldwork diary	Make daily notes – even if they are simple. Something is better than nothing. Ensure all docs have time, date, setting written on them.
Content analysis (Policy analysis)	A method to analyse documents and interview transcripts in this case national policies.	Identify and understand language, words, terminology used. Useful way to identify patterns and links to other data.	Requires perception and analytical skills Requires public availability of documents.	Use appropriate forms of analysis to research questions. Only use publically available documents, otherwise gain consent.
Household Surveys	Mix of open and closed questions to gather quantitative information about households	Establish baseline data about livelihoods to give a general picture of areas – identify characteristics and trends Cover a large area quickly	Can only be descriptive, cannot provide depth or meanings. One way conversations Language barriers	Follow up any issues arising in interviews or focus groups.

Table 4.3 Showing how each method (semi-structured interviews (SSIs), focus group discussions (FGDs) and household survey (HHS), policy analysis (PA) contributes to each research objective at different levels. Shaded boxes show no primary or secondary data were collected or analysed for those objectives.

	Research Objective 1	Research Objective 2	Research Objective 3	Research Objective 4
Household	HHS SSIs	HHS SSIs	SSIs	SSIs
Village	FGD	FGD	FGD	FGD
Sub-national (district and sub-county)	SSIs	SSIs	SSIs	
National			PA	

4.3.2 Stakeholder analysis

A stakeholder analysis was conducted before data collection. A stakeholder analysis enabled the identification of who the key interested and influential actors were across various governance levels (Reed et al., 2009). This also informed the selection of suitable methods to use to generate the required data.

Stakeholders can be defined as individuals, groups and organisations who are affected by or can affect a decision, issue or action (Freeman, 1984), which may include non-human and non-living entities or future generations (Reed et al., 2009). In this thesis, the term is used to refer to individuals, groups and organisations that had an interest in agriculture and climate change. Stakeholder groups vary across governance levels and have varying levels of interest and influence. Although there are many definitions and goals of stakeholder analysis (Donaldson and Preston, 1995), this thesis defines stakeholder analysis as the process of identifying and analysing individuals, groups and organisations who are affected by or can affect part of a specific decision, action or system (Reed et al., 2009).

Stakeholder identification was based on a wide analysis of grey literature, and from the researcher's prior knowledge and experience of working in Uganda. This method enabled different stakeholders at various levels to be included in the data collection process, this provided a useful way to understand the policy and institutional context at different levels (Kalaba et al., 2014). Additional documents and information were collected during a scoping trip to Uganda in June 2011. Reviewing these documents enabled the identification of additional stakeholders from the village to the national level. The stakeholder analysis provided a starting point for identifying potential local level research participants. Farmers were identified as the key stakeholders at the village level. Government officials and NGOs, were identified at the district level (district and sub-county). Using this approach ensured that a range of stakeholder perspectives from different levels were represented. Gaining a variety of perspectives also provided a way to verify or explore issues from both the 'top-down' and 'bottom-up' (Urwin and Jordan, 2008), an aspect highlighted as missing from existing studies and research designs (Chapter 3).

4.3.3 Sampling

The process of selecting research participants was based on the findings from the stakeholder analysis (Section 4.2). Different sampling strategies were used with different methods. For example, simple random sampling was used for the HHS. Snowball sampling was used to identify village elders in each of the villages who then helped to identify potential farmers for semi-structured interviews during Phase I and Phase II, and to identify FGD participants. Throughout this thesis, individuals who took part in the interviews are referred to as respondents, whereas those who took part in FGDs are referred to as participants. Some people (maximum one per village) were both respondents and participants. More about how each sampling technique was used for each method is provided under each relevant sub-heading in this section (4.2).

4.3.4 Keeping a field diary

Throughout the fieldwork (Phases I – III), a field diary was used to keep a day-to-day record of observations, thoughts and reflections. The field diary was divided into: descriptive notes that included a summary of the day; reflexive notes, which were personal thoughts, observations and reflections on the research process; and actions needed, which were a record of things that needed to be addressed based on the descriptive and reflexive notes. This provided a useful way of keeping track of events as well as providing context and additional insights during data analysis and interpretation (Creswell, 2008). Each Research Assistant also kept a field diary. This encouraged the Research Assistants to share experiences and reflect, adding additional insight to every day research activities and research findings. Field diaries were used as a planning tool, reflexive tool and act as a reminder of field activities. Therefore, primary data from field diaries are not included in the results and analysis.

4.3.5 Household survey

Questionnaires were used to conduct face to face household surveys. Although this added to research costs, it was the only practical means to conduct a survey of rural households. HHS also have the advantage of high response rates (Denscombe, 2010).

4.3.5.1 Household survey in Phase I

For the HHS, the sampling unit was the household. In line with other operational definitions used in Uganda, a household is defined *as "a group of persons who normally live and eat together. Very often the household will be a family living in the same house or compound and eating together"* (UBOS, 2001:5). Simple random sampling was used to identify households to allow for flexibility during data collection. In a random sample, every member of the population is equally likely to be included in the sample (Thompson, 2012). The sampling was conducted by going to every n^{th} house in the village. N varies across the study villages. N was calculated according to the number of households in each village to ensure that at least 25% of households were included: this is higher than is recommended by other studies (Tittonell et al., 2010). If the household was not available or willing to take part, then the next household was selected.

Questionnaires included both open and closed questions. Closed questions were used to collect primary data about household resources, livelihoods, and farming systems, including questions about the crop and livestock production systems and other agricultural and non-agricultural livelihoods. Open questions were used to allow respondents to justify their responses and also to capture data about past memorable events and experiences. The questionnaire was divided into three sections to collect data for research objectives 1 and 2: i) Demographic/household information; ii) Livelihoods and farming systems; and iii) The past (Appendix 3). The questionnaire was written in English, and then translated into local languages *(Lusoga* in Jinja District and *Ateso* in Soroti District) to ensure that research assistants both understood the concepts and used agreed terms to explain them. HHS were not used in Phase II or Phase III.

4.3.6 Participatory approaches

Participatory approaches can be used to share knowledge in a collaborative manner (Ballard and Belsky, 2010, Stringer and Reed, 2007). Capturing local knowledge and generating locally relevant insights are important for studies of adaptation (Roncoli et al., 2002), and participatory methods provide a way to achieve this (Patt et al., 2005). Participatory methods enable local people to participate by sharing their experiences and knowledge, which can help find solutions to local issues (Chambers, 1997).

Participatory methods were used throughout the various research phases to engage farmers in certain topics. Using participatory methods placed value on farmer perceptions, knowledge and beliefs, which are missing in existing ‘top-down’ studies of climate change and adaptation. In Phase I, participatory methods were used during FGDs to generate data about past and current issues, events, responses and weather patterns. In Phase II, participatory methods were used during semi-structured interviews with farmers to link 2030s’ rainfall projections with autonomous agricultural adaptations (Objective 3). More information about how participatory methods are used in each phase is provided in the respective sections below (Section 4.3.7 for FGDs and Section 4.3.5 for interviews).

4.3.7 Focus groups

Focus groups provide a useful way to stimulate discussions and add depth to the data (Stewart and Shamdasani, 1990, Creswell, 2008). They also provide an opportunity for participants to engage with a topic, rather than a simple two-way question and answer process, as is the case with questionnaires and interviews (Brockington and Sullivan, 2003). They enable the researcher to observe interactions and identify social phenomena, noting who is speaking as much as what they are saying (Krueger and King, 1998).

4.3.7.1 Focus Groups in Phase I

A series of FGDs were held in each village (Table 4.4). A protocol was developed for each and various participatory methods were incorporated (Appendix 3).

Table 4.4 List of focus group discussions held in each village during Phase I of data collection (a protocol for each FGD is provided in Appendix 3)

Title	Purpose	Methods	Participants	No. Of Participants
A) Intro. **(1 in each village)**	To generate contextual information about study villages, necessary for understanding farming systems.	Village resource map	Open meeting	Not specified
B) Livelihood analysis and current issues **(1 in each village)**	To understand current farming systems, identify key characteristics and existing challenges related to smallholder farming (Objective 1)	Causal diagrams and pairwise ranking	Groups of farmers (50% mixed sex; 50% women only)	10-15
C) Past Events and Coping **(1 in each village)**	To understand significant events and climate hazards experienced between 1960-2012 (Objective 2). To identify past responses, impacts and barriers to past responses (Objective 2).	Participatory timeline building and facilitated discussions	Groups of farmers (50% mixed sex; 50% women only)	10-15
D) Weather, climate and agriculture **(1 in each village)**	To understand normal climate conditions	Rainfall calendars and facilitated discussions	Groups of farmers (50% mixed sex; 50% women only)	10-15

One limitation of using FGDs is that certain powerful individual members can dominate (Brockington and Sullivan, 2003). This can mean that some views are not heard, which can serve to reinforce existing power dynamics and structures. To overcome this required skilled facilitation. Women were noticeably quiet in the mixed FGDs and their active participation in these groups was limited. Women-only focus groups were therefore held in half of the study villages to ensure that women participated, and created a comfortable environment in which women could speak freely. Taking such measures ensured that a variety of perspectives and attitudes were captured and allowed participation of both men and women overall.

Snowball sampling was used to identify village elders in each of the villages who then identified potential FGD participants. Cluster sampling was then used to ensure that village demographics, such as people of different ages, were represented. Participants for FGDs were recruited at the beginning of the fieldwork and participated in all subsequent FGDs. This meant that the same participants in each village took part in the FGD series. Occasionally, issues such as illness, death and other personal issues affected attendance. However, as each FGD was designed independently, this caused minimal disruption to data collection. FGDs were, however, ordered, to allow 'sequences' to evolve. Sequences are reported to be powerful tools due to their potential to increase the commitment of participants, triangulate data and foster mutual learning between the researcher and participants (Chambers, 1994). This also enabled the researcher to build relationships and trust with the participants so that they could talk openly about their experiences (Scheyvens and Storey, 2003).

4.3.7.2 Resource maps in Focus Group A

During introductory FGDs (A in Table 4.4), participants compiled village resource maps to provide general information about key landmarks and resources in the village. An example is provided in Figure 4.3.

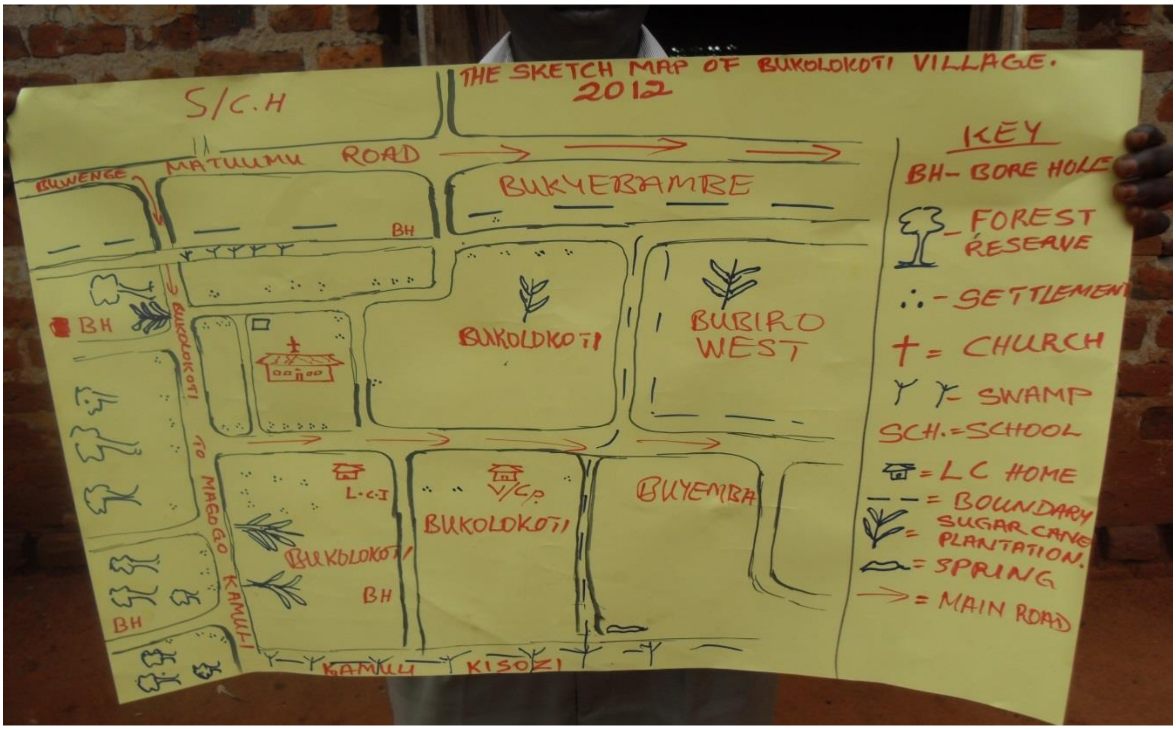


Figure 4.3 Village Resource Map, Bukolokoti Village, Jinja District, March 2012.

4.3.7.3 Causal Diagrams and Pairwise Ranking in Focus Group B

Both causal diagrams and pairwise ranking were used to identify and discuss problems. These methods are widely used as a way to engage farmers in the planning, implementing of activities, and therefore support participatory farm management (Dorward et al, 2007). In this thesis they were used to explore and prioritise the relationships between different problems experienced by farmers and identify the most significant factors that shape farming systems (Objective 1).

Pairwise ranking is commonly used to identify and prioritise important factors. In this thesis pairwise ranking was used to facilitate discussions about farming systems and the current challenges farmers are experiencing. In the focus group settings, problems were listed, then pairwise ranking was used to systematically compare problems and create a final list of ranked problems for each focus group (e.g. see Figure 4.4). The ranked lists provided data about the challenges farmers are experiencing, while the discussions during the ranking process were also important. Discussions were translated into English, enabling notes to be recorded and probing questions to be asked. Discussions were also digitally recorded and transcribed. These discussions provided important insights into the priorities of different groups and connections between the various problems identified.

Figure 4.4 Results from pairwise ranking activity, Agirigiroi Village, Soroti District, May 2012.

One of the challenges in using pairwise ranking is that the interconnected nature of problems is overlooked. As this thesis is informed by systems thinking, addressing this weakness was important. Therefore, two out of the eight focus groups (one in each district) also used causal diagrams to explore problems. The process followed was based on that reported by Galpin et al. (2000). In these focus groups where causal diagrams were used, farmers discussed, listed and scored their problems. A symbol was then drawn for each problem on a piece of paper. Symbols were then organised on a board to identify relationships. Arrows were drawn between symbols to represent the cause and effect relationships between these different problems. Through this process, further problems and their causes and effects were added to the diagram. From the discussions a final diagram was produced (see Figure 4.5 for an example). In addition to this, the diagrams were used as a tool to facilitate discussion and generated in-depth insights into how farmers perceived the interconnected nature of problems. This process produced diagrams of the farming system, enabling the exploration of how various components interact and provided a useful way to examine the relationships between the problems farmers were experiencing.

Figure 4.5 Causal Diagram, Idoome Village, Jinja District, April 2012.

4.3.7.4 Timelines in Focus Group C

Timelines were also constructed during FGDs (Figure 4.6). Participatory timeline building provided a useful way to gather data about climate extremes, which were then checked against secondary data, where it was available. Building timelines in a participatory setting enabled the researcher to elicit different experiences of climate extremes and the drivers, impacts (short and long term) and responses associated with each hazard.

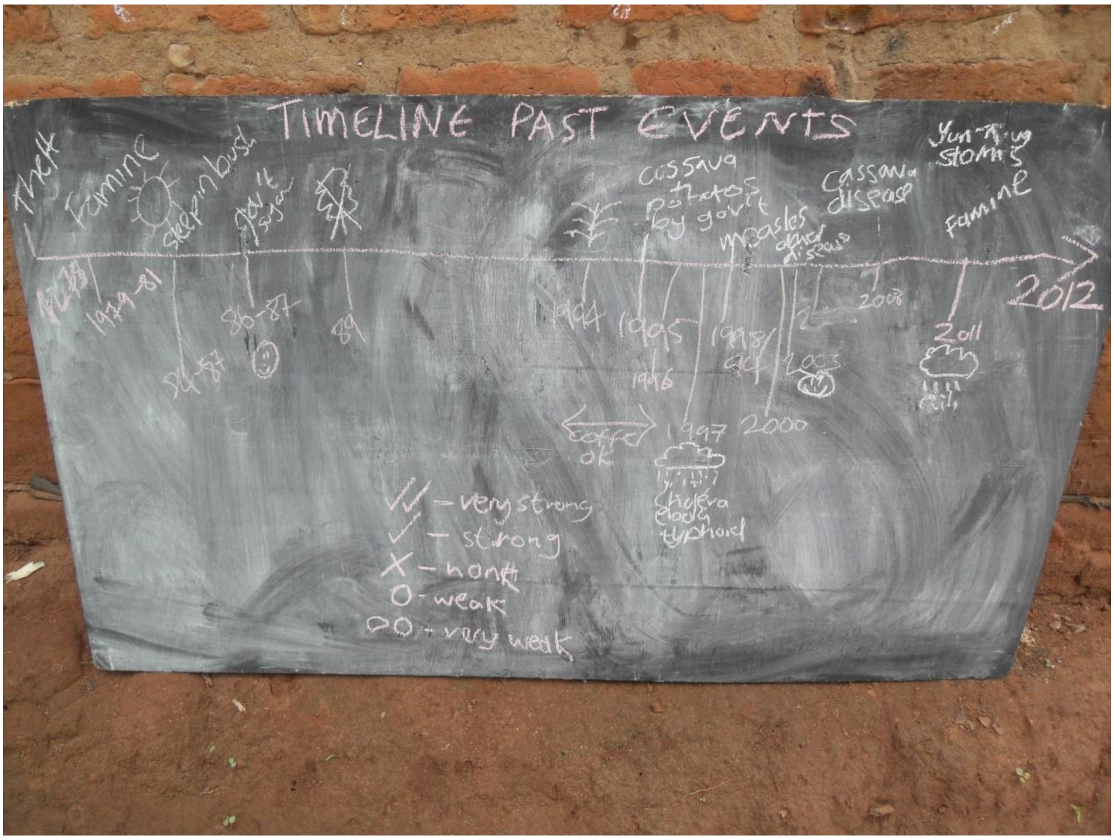


Figure 4.6 A timeline constructed during a focus group, Bukolokoti Village, Jinja District, 2012

4.3.7.5 Rainfall calendars in Focus Group D

Rainfall calendars were used during FGDs to establish farmer perceptions of a 'normal' climate, both in terms of rainfall and temperature. The concept of a 'normal climate' then provided a starting point to facilitate discussions about farmers' experiences of past climate variability and climate changes (Objective 2), as well as broader changes in farming systems (Objective 1). Farmers were also asked open questions about changes in rainfall and temperature in recent years (last 5 years), compared with their perceptions of a 'normal climate'. Climate was selected as a focus, as opposed to weather, as it refers to longer-term trends in average weather which farmers were describing. Further open questions were asked during FGDs to explore farmer responses in order to ascertain how they had operationalised adaptive capacity.

Although the rainfall calendars also considered temperatures, farmers found it difficult to remember temperatures and tended to use their memories of rainfall to estimate temperature. Difficulties in translating and discussing details surrounding temperature changes with farmers were also experienced. Therefore, this thesis predominantly focuses on rainfall.

Focus groups were not used in Phase II, therefore the next section moves directly onto their use in Phase III.

4.3.7.6 Focus groups in Phase III

A sample of community members were selected to take part in these final FGDs with the assistance from local leaders using cluster sampling. Cluster sampling included representatives from the local leadership, women, youth and elders, who had previously attended. This ensured that farmers were able to discuss and validate the researchers' interpretations and recordings of the data that they provided.

This process facilitated discussions about data inconsistencies (cf. Simelton et al. (2013) and addressed issues associated with memory (cf. Marx et al. (2007)). Disparities identified during previous data collection were discussed to triangulate the data. Any contradictions that emerged between data sources were discussed in groups to agree on a consensus. Issues where consensus could not be reached are reported in the relevant results chapters, and cross-checked with secondary data where possible. For example, a couple of issues emerged with dates of particular events. In some cases secondary data such as government reports were consulted or a range of dates were reported in the results chapter. Additionally, through this validation process, the HHS data from Jinja District was deemed to be invalid by participating community members and has therefore not been included in the analysis.

Findings from the HHS about farming systems, agricultural practices, asset ownership and livelihoods were presented to the focus groups in each village. Those aspects were selected as they were important to addressing specific research questions and providing context to the research findings. Findings from the HHS were communicated in a way that participants could understand, for example *"1 out of every 4 households grows cassava"*, or *"more than half of households use chemical fertilisers"*. Focus group participants in all four villages in Soroti District agreed with the data they were presented with, which was taken as an indication that the survey data were valid. However, this was not the case in the focus groups in Jinja District.

Significant discrepancies emerged between the findings from the HHS and the opinions of focus group participants. These discrepancies were discussed in-depth during the focus groups. It became clear that resolving the discrepancies was complex and would rely on the researcher making an informed judgement.

To make an informed judgement, discrepancies were also discussed with agricultural extension workers, as local experts, and with the research assistants who conducted the survey in both districts. Personal observations were also drawn upon. A number of different possibilities emerged:

1) Focus group participants wanted to cause problems for the research team – this was described as 'local politics';
2) Households who took part in the survey may not have given accurate information – households may have been unsure of the purpose of the research and therefore may have been suspicious of how the findings would be used. During the discussions, local experts said that there was growing concern about government taxes on land and agricultural commodities in Jinja District;
3) The questionnaire tool was not sufficiently appropriate to the local context – respondents may have provided inaccurate responses because they did not understand the questions, or the survey involved too many questions which resulted in respondents being tired and/or bored;
4) The research team did not carry out the survey in the agreed manner, for example the research team did not understand the tool, sampling or the survey process; the sample of households included may not have been random; time constraints and logistical challenges, such as rain, meant that research assistants did not ask all of the questions, assumed certain answers and therefore filled the HHS in inaccurately.

Prior to the fieldwork, a number of these potential issues had been considered and had been factored into the research design and data collection process to minimise the risks, for example:

- Two research assistants collected data within the same district – 2 villages per research assistant;
- Training was provided to research assistants, which included translating the HHS questions;
- The HHS was conducted at times convenient to households and research assistants;
- Local leaders were used as an entry point and held introductory village meetings in each study village to inform people about the research and obtain consent.

More details about the use of research assistants and the concept of validity are provided in Section 4.5 and Section 4.6 respectively.

To make an informed decision, the evidence for each of the four options was considered and triangulated with observations, for example by observing what crops were visible at the time of fieldwork, and by discussing them further with the research assistants. Option 1 was rejected in the basis that it was unlikely that focus group participants in all of the villages, some of which were more than 30 km apart, would consistently cause problems for the research team. Valid responses were obtained in Soroti District using exactly the same questionnaire, suggesting that the problem was unlikely to be with the tool itself, thus ruling out Option 3. Research assistants, who had experience of conducting research in Uganda, provided reassurance that they had conducted the HHS as agreed in the training. However, it was not possible to verify this. Research assistant error could explain some of the inconsistencies. However, discrepancies were related to all villages and not to one particular research assistant, meaning that Option 4 was unlikely to be the only reason.

As the invalid data related to crops, agricultural practices, and asset ownership (including land), it is possible that households who took part in the survey did not want to disclose such sensitive information. Efforts were undertaken to explain the purpose of the research in each village, and before every HHS. However, in one particular village, one of the research assistants encountered issues with distrust, where community members suspected him of conducting research on behalf of the government. As NGOs operate in the area, and have previously conducted surveys, some respondents may have been experiencing research fatigue, where they no longer see the value in providing accurate information, or they could have provided answers to obtain access to other programmes and services, rather than reporting on their actual situation. In summary, it was decided that there were multiple potential reasons for why respondents could have provided false information (Option 2), and the possibility of research assistant error could not be discounted.

Despite efforts to take into account contextual factors, to mitigate these potential issues in the research design and data collection process, and using multiple ways of triangulating the data, the validity of the HHS data remained questionable. Large uncertainties about the validity of the HHS data remained, and there were too many inconsistencies between the presented HHS data and the opinions of the focus group participants that were impossible to verify; thus justifying the use of any of the survey data was deemed to be too difficult. Therefore the decision was made not to use any of the HHS data from Jinja District.

4.3.8 Semi-structured interviews

Semi-structured interviews are a flexible research tool that also allow interviewees to direct the interview process (Gillham, 2000). An advantage of semi-structured interviews is that they allow the researcher to expand questions to gain additional insights and to follow up on any points that emerge (Mitchell and Jolley, 2010). Such considerations were important for exploring questions of ‘what’, ‘how’ and ‘why’ which were needed to fully address the research objectives of this thesis. Other research suggests that people are more likely to talk honestly and openly about certain topics during individual discussions rather than during group meetings, due to the culturally sensitive nature of certain topics (Orr and Mwale, 2001).

Semi-structured interviews with farmers at the village level were undertaken during both Phase I and Phase II (Section 4.3.8.1). During Phase II, semi-structured interviews were also conducted with both government and non-government policy actors at the sub-national (district and sub-county) level (Section 4.3.8.2). Participatory methods were used during semi-structured interviews with farmers in Phase II to link 2030s’ rainfall projections with autonomous agricultural adaptations (Objective 3). Further benefits of using participatory approaches are outlined in Section 4.3.6.

4.3.8.1 Semi-structured interviews in Phase I

Phase I of fieldwork focussed on understanding past (1960-2012) and present issues associated with farming systems, adaptation and climate hazards. Semi-structured, in-depth interviews were carried out with farmers in each of the villages. During the interviews, an oral history approach was taken to collect historical information about the broader context in which farming systems are situated (Dunn, 2010). Oral history narratives also enabled the exploration of the temporal dynamics of farming systems (Objective 1) and past climate hazards (Objective 2). Semi-structured interview protocols, for the farmers (Appendix 3) were developed to include general, contextual questions, as well as specific questions about current farming systems and livelihoods, past events and changes, links between weather and agriculture, and policies, governance and institutions.

In Phase I, all of the village-level interviewees were farmers, though some of the interviewees were also local leaders and part of the LC1 Council (details on the how this fits with decentralised government structures were provided in section 3.4.5). Farmers were identified using snowball sampling and included both males and females. Age was also taken into consideration to ensure that all age groups were represented. Representation of both middle aged and younger interviewees was important to this research as it looked at the past, current issues as well as possible future responses. Elderly men and women were able to provide historical context and were knowledgeable about agriculture. Middle aged and younger respondents were able to provide information about contemporary issues.

On average, interviews lasted an hour. In particular, farmers discussed trends in farming system evolution, drivers of change and the impacts of such changes on current systems of farming. They were also asked questions about specific events which had impacts at a household level, where specific information about the event, impacts, and responses was collected. Interviews further provided insight into local cultural beliefs and local knowledge about weather and farming. They allowed for discussions about sensitive issues, for example conflict, and political instability. In Soroti District, such issues emerged as having important implications for the evolution of farming systems.

4.3.8.2 Semi-structured interviews in Phase II

During Phase II, semi-structured interviews were also conducted with policy actors representing both government and non-government actors at a sub-national level (Table 4.1). This included actors working at both district and sub-county levels. At the sub-national level, purposive sampling was used to select policy actors for initial interviews, which was followed by snowball sampling for additional interviews, where interviewees provided contact details of possible other relevant policy actors. Snowball sampling was used to identify relevant and knowledgeable people able to provide in-depth information on a topic (Patton, 1990). In total, 17 semi-structured interviews with sub-national policy actors were undertaken during Phase II (Table 4.1). Policy actors included those involved in planning, financing and implementing programmes related to agriculture and natural resources. Interviews lasted around one hour and were carried out in English.

Interviews with policy actors were conducted to elucidate additional opinions about agriculture and collect data about current challenges in the agriculture sector, policy-making processes and policy implementation. Interviews provided additional insight into how the decentralized governance systems work in practice, highlighting vertical and horizontal linkages. For interview protocols see Appendix 4. The researcher used these topics as a guide, however, interviews were flexible and also allowed issues that were raised by respondents to be discussed (Dorussen et al., 2005).

In total, 17 semi-structured interviews were also conducted with farmers during Phase II (Table 4.1). Farmers were selected to take part in the interviews with the help of local leaders, who acted as key informants to identify farmers that represented the different demographic and socio-economic characteristics of the area. Interviews with farmers were used to explore agricultural adaptations to 2030s' rainfall projections.

2030s' rainfall scenarios for Uganda were developed from a review of secondary data (see Section 4.3.9.2 for a description of how these scenarios were developed). Since the 1970s, scenario storylines have been used in analysing complex environmental problems and solutions (Rounsevell and Metzger, 2010) as they can help to facilitate communication (Rosentrater, 2010). This makes them useful tools to explore decision-making.

Rainfall projections for Uganda suggest that variability will increase in the future, yet the complexities of the global climate system make the exact nature of future changes and variability difficult to determine (Christensen et al., 2007). In this thesis, therefore, different 2030s' rainfall scenarios were developed to capture the range of possible rainfall scenarios (Table 4.5). 2030s' rainfall projections informed the development of four rainfall scenarios that were characterised by the expected onset of the rains and the monthly totals. More about how these rainfall scenarios were communicated to farmers is provided in Chapter 7.

Table 4.5 Description of 4 2030s rainfall scenarios adapted from data provided by McSweeney et al. (2008),

Scenario	**Round / Season**	**Onset**	**Seasonal amount (monthly total)**
Baseline	Baseline Round 1	Normal	1974-2005 District level baseline data[2].
Delayed-	Round 3, Season 2	Delayed	Below normal (-8 -18%)
Delayed+	Round 3, Season 1	Delayed	Significantly above normal (+23 +26%)
Timely-	Round 2, Season 2	On time	Below normal (-5 -12%)
Timely+	Round 2, Season 1	On time	Above normal (+15 +23%)

[2] Downloaded from http://www.fao.org/giews/english/ierf/list.asp?code=253 (NOAA/FewsNet, 2012)

4.3.8.3 Seasonal crop calendars

During semi-structured interviews in Phase II, seasonal cropping calendars were used to link 2030s' rainfall projections with agricultural adaptations. Farmers described important decisions at each point in the seasonal cycle (see Appendix 4 for a summary of the key decisions). This approach was designed to capture how farmers would respond to different rainfall projections and also discuss the implications of providing weather forecasts.

Seasonal crop calendars are a participatory method that can be used to elicit decisions on crops and their sowing period, management decisions and other agro-ecological dimensions. They were used in this research to identify the crops grown by each farm household, to explore the temporal dimensions to management practices (Binns et al., 1997) and how these may change under different rainfall scenarios. The first step was to collect demographic and socio-economic data. The second step involved producing a seasonal calendar for a 'normal' year. A 'normal' year was based on the monthly mean rainfall amount for the 1970-99 baseline presented in McSweeney et al. (2008). Rainfall projections were communicated to farmers for each month both visually using bar charts (e.g. Roudier et al., 2014) and were described in the local languages. A series of questions were asked alongside the projections to capture any changes in agricultural management practices (Appendix 4). Seasonal crop calendars were also filled in by the researcher during semi-structured interviews to record how farmers would respond to 2030s' rainfall projections. The process was repeated for each of the rainfall scenarios in Table 4.5 to explore how farmers would respond. This resulted in a seasonal crop calendar for each rainfall scenario.

Semi-structured interviews were not conducted during Phase III.

4.3.9 Secondary data

To achieve Objective 3, integration of secondary data and analysis was required. National policies were analysed to examine the links between planned and autonomous adaptation. Secondary data were also used to triangulate findings about past climate hazards (Objective 2) and to generate the 2030s' rainfall projections used in semi-structured interviews conducted in Phase II (see Section 4.3.8.2).

4.3.9.1 Secondary data in Phase I

Secondary data from grey literature were used to identify past climate hazards in Uganda. This provided a way to triangulate empirical findings from primary data.

4.3.9.2 Secondary data in Phase II: 2030s' Rainfall Projections

As Section 3.4.2 highlights, accurate, long term meteorological data in Uganda is limited (Osbahr et al., 2011). This limited the ability of the researcher to analyse existing data to develop 2030s' rainfall scenarios. Instead, a review of existing climate projections for Uganda was undertaken.

According to McSweeney et al (2008), rainfall projections for the 2030s suggest changes in monthly totals in the range of -18% +26% (Table 4.6). The largest rainfall increases are projected for January and February, which also has the largest range between minimum and maximum values (McSweeney et al., 2008); this is consistent with other studies (USAID, 2013). Although alternative 2030s' rainfall projections are presented by USAID (2013) and IPCC (2013b), these were not available before fieldwork and do not provide the necessary level of detail required to develop rainfall scenarios that could be discussed with farmers. However, the review of climate trends presented in Section 3.4.2 demonstrates that 2030s' projections provided by McSweeney et al. (2008) are consistent with recent studies.

2030s' rainfall projections were taken from McSweeney et al. (2008), which are produced on a monthly timescale (Table 4.6). 2030s' rainfall projections used in this thesis as a basis for the rainfall scenarios (Table 4.5) were developed at a monthly timescale to represent seasonal characteristics including the onset, cessation and seasonal totals, which is also compatible with use of seasonal calendars (Section 4.3.8.3). This provided the necessary level of data to capture seasonality of rainfall in Uganda (Section 3.4.1). 2030s' projections were used to calculate monthly totals and determine the level of change when compared with the observed mean 1970-99 baseline (Table 4.6): i.e. whether the rainfall would be average or near normal (-/+5%); below average (>5- <-20%); significantly below average (>-20%); above average (>5<20%); and significantly above average (>+20%).

Sub-national baseline data for each district was obtained to take into account differences between the rainfall patterns in Soroti and Jinja District. Percentage changes from McSweeney et al. (2008) were then to applied to quantitative estimates of district rainfall derived from Cold Cloud Duration imagery and data on observed rainfall (GTS-Global Telecommunication System by the NOAA Climate Prediction Centre) [3]. More about how these rainfall scenarios were communicated to farmers is provided in Section 7.2.1.

Table 4.6 Projected percentage change (%) in rainfall for Uganda in 2030s compared with observed mean (baseline 1970 – 1999) under SRES Scenarios A2, A1B, B1. Taken from McSweeney et al. (2008)

	SRES	Minimum	Median	Maximum
Annual	A2	-7	3	11
	A1B	-4	2	11
	B1	-3	1	14
January / February	A2	-5	0	18
	A1B	-18	9	26
	B1	-9	2	26
March / April / May	A2	-7	2	19
	A1B	-8	4	15
	B1	-11	1	23
June / July / August / September	A2	-11	0	23
	A1B	-12	1	18
	B1	-5	-1	15
October / November / December	A2	-5	3	13
	A1B	-5	5	15
	B1	-4	4	16

[3] District level data downloaded from: http://www.fao.org/giews/english/ierf/list.asp?code=253 (NOAA/FewsNet, 2012)

4.3.9.3 Secondary Data in Phase III: Policy analysis

In this research, content analysis of policy documents provided a top-down perspective while data from semi-structured interviews with policy actors provided additional insights into how these policies were designed and implemented. A combination of these two approaches has been recommended for understanding public policies (Urwin and Jordan, 2008) and their implementation (Fraser et al., 2006). Policy narratives were constructed from this integrated approach (Roe, 2006), using deductive content analysis to compare policies (Krippendorff, 2004). This required the researcher to develop a set of questions (see Appendix 5), which then provided a structured way to analyse and compare data (Richards, 2009).

4.4 Primary data analysis

Data were input, transcribed and processed at the earliest opportunity to avoid misinterpretation and ambiguous notes. Data analysis is a process of making sense of the data (Silverman, 2000). There are various approaches to analysis and interpretation (Rossman and Rallis, 2003). In this thesis, data were analysed iteratively. This involved the identification of initial trends and patterns, which were refined during the analysis process (Richards, 2009). The selected methods used to address the research objectives produced both qualitative and quantitative data, which required a range of strategies to analyse and integrate different types and sources of data. A brief summary of data analysis is provided in this section. However, each results chapter presents an overview of how data were integrated to address each research objective.

4.4.1 Quantitative data analysis

Quantitative data from the HHS was entered into a Microsoft Excel 2010 spreadsheet, where it was screened and cleaned. Initial checks were completed using the Microsoft Excel 2010 'filter' function along with 'search and replace'. A database consisting of 873 entries was created. The Microsoft Excel 2010 document was then analysed. During the analysis stages, data were cross tabulated to explore trends in the data and provide contextual information. This meant that quantitative data from the HHS could provide information about farming systems and trends in farming system evolution, thus contributing directly to Objective 1. Household survey data from Jinja District were deemed invalid during Phase III, which left a database of 373 entries from Soroti District.

Quantitative data were also generated from some of the participatory methods. Data from rainfall calendars were input into a Microsoft Excel 2010 spreadsheet to understand a normal climate and explore changes over time. A range of graphs was produced from this dataset. Rainfall calendars across the different villages were compiled to produce mean results for each study district; this resulted in bar graphs showing the average climate conditions for each study district.

Other quantitative data were produced from the seasonal calendars and used to explore 2030s' rainfall projections. The response to each rainfall scenario was captured on a seasonal crop calendar (Figure 4.7). Data from the recording sheets were analysed quantitatively to calculate the number of changes compared with the baseline. Farmers were grouped into categories according to the total number of changes made in response to the rainfall scenarios. Farmers were then categorized according to the nature of the production system, i.e. the extent to which they were subsistence or market oriented farmers. This process enabled the identification of patterns, which resulted in the stratification of farm households into various groups. Details on the groups are presented in Chapter 7.

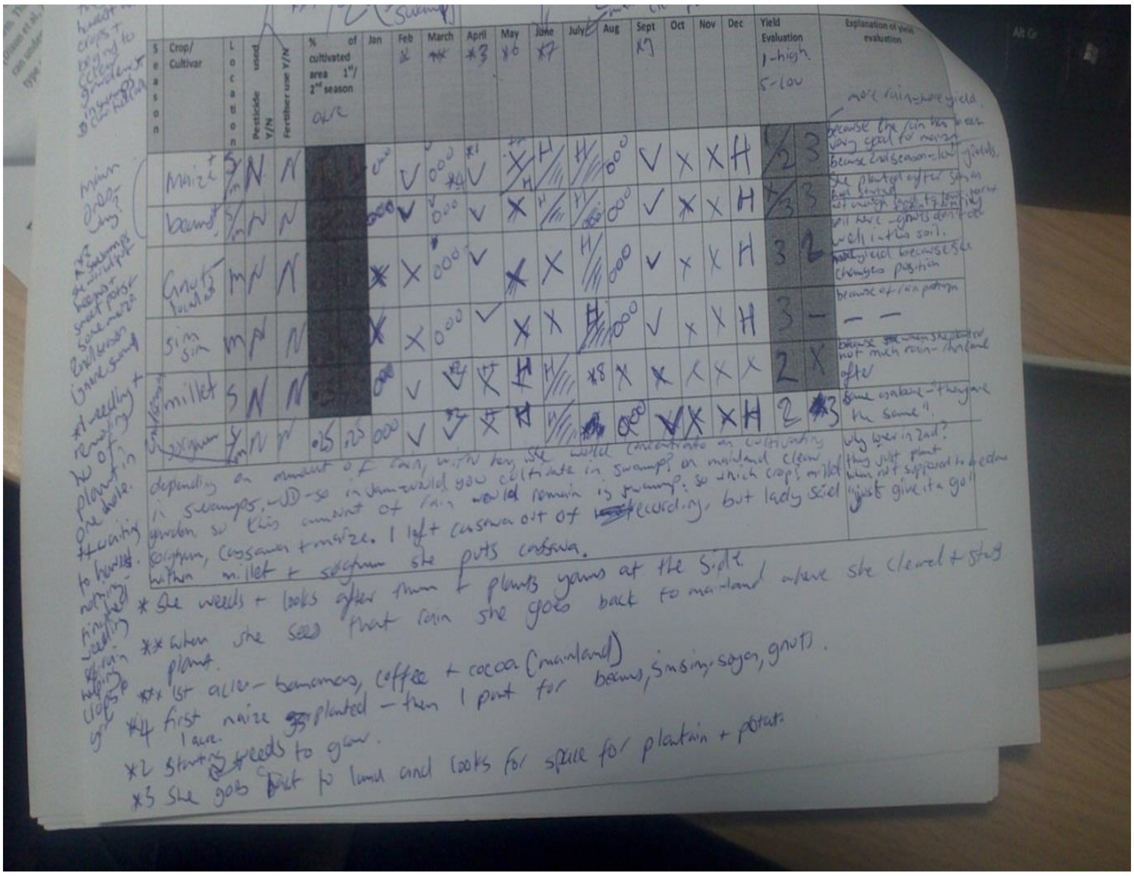


Figure 4.7 Example recording sheet for the seasonal calendar for one round of the rainfall projections.

4.4.2 Qualitative data analysis

In qualitative research, the role of the researcher is to interpret and give meaning to the data (Neuman, 2003). Analysing qualitative data generally involves getting to know the data (immersion), organising the data into themes and patterns (coding) analysis and bringing meaning to the chunks (interpretation), then writing it up into a meaningful story (Rossman and Rallis, 2003). Various approaches were employed to analyse qualitative data and integrate data from different sources.

All focus groups and interviews were digitally recorded and transcribed. Qualitative data were coded and indexed through iterative content analysis, where major themes emerged from the data (Saldaña, 2009). Iterative content analysis works upward from the data (Richards, 2009). Multi stage coding was used to explore the data, identify themes and link themes in order to build categories and develop concepts (Saldaña, 2009). These stages reflected different types of coding: descriptive, topical and analytical. Using a multi-step process enabled the researcher to become familiar with the data and learn from it.

Content analysis was used as a systematic approach to identify and describe phenomena that emerged from the coding process (Krippendorff, 2004). Timelines, livelihood trajectories and tables were used to organise data and integrate data from different sources (Sallu et al., 2010).

4.5 Research assistants, positionality, and ethics

Conducting case study research and collecting data in a cross-cultural context raises a number of issues associated with working with research assistants, positionality, and ethical considerations. This section presents a personal reflection on these issues and summarises their implications for the research process and outcomes.

4.5.1 Research assistants

Two Research Assistants were employed in each study district to assist with data collection. Specifically, their role was to translate the research tools into local languages *(Lusoga* in Jinja District and *Ateso* in Soroti District), conduct the household survey, and act as translators during data collection at the village level. Before beginning the research, training was provided to give them background information on the research topic and research process, as well as to provide specific skills in the use of surveys, interviews and focus groups, and translation of research tools. During the training, issues of reflexivity, positionality and ethics were also covered (see Sections 4.5.2 and 4.5.3).

To realise the full potential of data collection in a cross-cultural context, the researcher needed to understand relevant social, cultural and political context in order to interpret the data (Brockington and Sullivan, 2003, Scheyvens and Storey, 2003). Daily discussions and reflection with Research Assistants provided a systematic way of addressing this issue, highlighting the important role that Research Assistants played in the research process.

Under my supervision as the lead researcher, Research Assistants conducted the HHS. The researcher conducted all FGDs and semi-structured interviews in English to ensure consistency. Research Assistants translated questions into the local languages, then translated responses back into English. At the village level, semi-structured interviews and FGDs were conducted in either *Lusoga* or *Ateso*.

Although concerns over translation errors are always present, efforts were made to reduce these. Language barriers, the risk of misinterpretation and semantics were important considerations (Smith, 1996). Language plays a central role in the construction of meaning, which may be lost through translation (Müller, 2007). Multiple Research Assistants translated both the interview protocols and focus group guides, agreeing in advance of data collection, a written, harmonised version and a glossary of key terms.

Translating FGDs and semi-structured interviews between English and local languages presented another challenge, meaning that some nuances still may have been lost in translation (cf. Simelton et al., 2013). During FGDs two Research Assistants were present to help with facilitation and translation, to ensure that nothing was missed or misinterpreted. All semi-structured interviews were digitally recorded. Research Assistants were then able to listen back over interview recordings and note down any discrepancies in translation. All Research Assistants were farmers and were knowledgeable about agriculture and familiar with the local areas. This meant that they could explain complex points which meant that they were better able to relate to all respondents and participants (Twyman et al., 1999). In addition to excellent knowledge of the English language, all Research Assistants had previously been involved with research and had experience in acting as translators.

4.5.2 Positionality

Positionality is the social position of the researcher in relation to the participants involved in the research process. It is influenced by a number of factors, including race, gender, family status, education, class and others social identities (Skelton, 2001). This requires the researcher(s) to be aware that his/her own identity and positionality will shape the interaction between the researcher and the researched. Positionality has the potential to influence both the research process and outcomes (Twyman et al., 1999).

Throughout the research process, I introduced myself as a student from the University of Leeds in the UK. Being a young, white female from the UK will have undoubtedly influenced how people perceived me. Perceptions were linked to other experiences of 'white' people who had visited the villages, such as NGO staff and volunteers. People in the study villages associate being white with being wealthy and this had the potential to influence the production, interpretation and representation of their knowledge. Initially, these perceptions meant that community members in the study villages are likely to have viewed me as an 'outsider'.

It is assumed that obtaining 'insider' status, where the researcher holds a similar position to those being researched, is desirable and beneficial. For example, Mather (1996) argues that it produces closer, more direct and truer knowledge. However, as Herod (1999) illustrates, being both an 'insider' and 'outsider' has potential drawbacks and benefits During their training, Research Assistants were also briefed on the importance of positionality (Section 4.5.1). By working together with Research Assistants, we were able to discuss and recognize the potential issues to do with positionality, and take measures to minimize the influence it had on the research process and outcomes.

Many people before me, including white researchers, had made one off visits or failed to fulfil commitments to research participants, which provided little opportunity to gain build relationships or obtain feedback and in some villages had led to distrust (Twyman et al., 1999). By spending a lot of time in the villages, staying overnight and interacting with people over an eight month period, it meant that I was able to challenge some of the potentially negative perceptions of researchers. During this time I also participated in various daily activities such as collecting water, buying food in the local trading centres and cooking on a charcoal stove. To further build trust, repeated trips to the study villages throughout 2012 and 2013 were made, where I was also able to report back and verify findings in 2013. My positionality undoubtedly changed over time as rapport, empathy and trust was built.

From previous experience of living in Uganda, I was aware of some of the cultural sensitivities that may arise with different stakeholder groups. Research Assistants were also familiar with cultural norms, behaviour and expectations. A number of other measures were put in place to reduce any power imbalances and the potential negative impacts of the research team's positionality. For example the research team would: respect local dress code and appearance, such as long skirts for women and long trousers for men; approach potential participants and respondents in a locally sensitive manner; arrange meetings at appropriate times and in places suggested by participants; try to sit at the same levels as respondents during interviews and participants in the focus group discussions; and finally, be honest about the purpose of the research and reiterate that there was no hidden agenda or remuneration for taking part in the research. These measures also provided a way to ensure that all participants were informed about the research and felt at ease and comfortable with the presence of the research team.

4.5.3 Ethical considerations

Given that this research involved human participants, a number of ethical issues were considered. Prior to the research being carried out, a full risk assessment and ethical review were conducted. This study was approved by the University of Leeds Ethics Review Committee (Ref. No. AREA11-059) and cleared the necessary risk assessment procedures before data collection began (Appendix 2). The ethical considerations provided a way of safeguarding the research participants, the research process and the credibility of the research findings (Flick, 2009). The broad ethical issues considered in this thesis were centred on obtaining consent and confidentiality.

Local leadership structures were respected in order to ensure that relevant personnel at all levels of local government were aware of the research and the presence of the research team in the area. In both study districts, I obtained support from individuals in the district local government, who were able to provide additional supporting letters to the official 'letters of introduction' that I had obtained through the Uganda National Council of Science and Technology (UNCST).

At the village level, local chairpersons and other respected members of the community, such as head teachers, were consulted. This enabled the research team to introduce themselves, the research, and obtain the necessary permission. These initial contacts also helped with later organisation of and mobilisation of the people for the introductory community meetings. Introductory meetings were conducted in each village upon arrival. These were held to inform people living in the villages about the research, answer any questions they had, and also to obtain their consent.

During introductory meetings, informed consent was obtained verbally following a full introduction to the research and the research team. The background to the research was fully explained in an open format so that all those present were able hear what the research was about and ask questions. My previous experience working in Uganda had taught me that this is an effective way to work with communities. Through careful explanations of the research, I demonstrated that that I was independent but in communication with other stakeholders, for example, local government extension services and NGOs. This openness provided an opportunity for those who may not specifically be involved in the research to know why the research team was present. It also proved to be a useful way of communicating information, and provided a platform for people to ask questions. People in all of the villages asked questions about the research before they agreed to participate. One village in particular was very dubious about research, following past bad experiences. However, consent from the villagers was obtained after introducing myself and the research team and explaining more about the research.

In addition to the initial introductory meeting, full introductions were given at the beginning of each HHS, semi-structured interview, and FGD. The implications of participation were explained, so that potential respondents were able to make an informed decision (Guillemin and Gillam, 2004). Everyone who took part was made aware that no promises about the impacts of the research could be made and that we were unable to guarantee that research findings would be considered or acted upon in the future (Twyman et al., 1999). Instead a commitment was made to share and communicate these findings in the study villages and with other stakeholders.

For stakeholder interviews and stakeholder focus groups conducted at the sub-national level, as well as a verbal introduction, an information sheet was provided. Interviewees were then asked to sign the sheet to confirm that it had been understood. In all situations, people were given the option to ask questions before they gave consent and were assured that they could withdraw at any time. In accordance with procedures outlined in the ethical review, research participants were not paid, thus, all who participated did so on a voluntary basis.

All respondents and participants were ensured full anonymity and guaranteed that their responses were confidential: the research findings would only be used for academic purposes and names would not be used to identify individuals. Research codes were used instead of taking names. To comply with confidentiality, hard and electronic copies of raw data were not shared with anyone outside of the research team. Electronic data were also stored on encrypted external data drives and password protected computers for a short period, before being transferred onto the University of Leeds system.

4.6 Validity

Reliability and validity are important as a means to convince the audience that the research findings of an inquiry are worth paying attention to (Lincoln and Guba, 1985). The concepts are interdependent, i.e. there can be no validity without reliability, and together reliability and validity can lead to generalizability (Lincoln and Guba, 1985). However, these concepts can have different meanings in quantitative and qualitative research (Golafshani, 2003). In this study, four concepts were applied to demonstrate the quality of case study research: construct validity; internal validity; external validity; and reliability. Construct validity refers to the correspondence between inferences and interpretation, i.e. the constructs, and the empirical evidence (Peter, 1981, Yin, 2009). Internal validity considers inferences made about causal relationships within the study, for example, cause and effect relationships that are identified are not the result of other causes. Internal validity can be thought of as a ‘zero generalizability’ concern (Kozlowski, 2012). External validity refers to whether the observations, insights and conclusions drawn from the case study or population can be applied to other contexts, beyond the immediate case study (Yin, 2009). The goal of reliability is to ensure that if another researcher followed exactly the same procedures the same findings and conclusions would be drawn (Yin, 2009). Strategies were implemented to ensure that the findings generated by this case study met these criteria (Table 4.7). The decision not to use HHS data (as discussed in Section 4.3.7.6) provides an example of how the validity criteria were applied in this thesis.

Table 4.7 Validity criteria and strategies undertaken to address them (adapted from Blaikie, 2010, Yin, 2009)

Concept	Implemented strategy
Construct validity	Used mixed-methods approach to ensure multiple sources of evidence were used. Clear data collection and analysis process and procedures. Participants engaged to verify preliminary findings.
Internal validity	Analysed data to identify patterns, explain patterns and any conflicts identified. Explained and commented on anomalies or unexpected patterns and/or conflicts.
External validity	Compared findings with other studies.
Reliability	Developed standardized household survey, interview protocols and focus groups discussion protocols.

4.7 Summary of Chapter 4

This chapter has outlined the data collection process and the methods used to address the research aim and objectives. The stakeholder analysis and sampling techniques have also been described. Methods and how they were used during each phase of data collection are detailed and the strategies used to analyse and integrate different types and sources of data to address each research objective are outlined. Finally, working with research assistants, positionality, ethical consideration and validity have been discussed, and how they may have influenced the research process and outcomes has also been reflected upon. The remainder of this thesis presents and discusses the results obtained during research process outlined in this chapter.

Chapter 5 Farming system evolution and adaptive capacity: Insights for adaptation support[4]

Abstract

This chapter addresses Objective 1 and investigates how historical trends in farming system evolution (1960-2012) have influenced farming system adaptive capacity using data from household surveys, semi-structured interviews, FGDs and observations, all collected from the village level. It provides a brief summary of current farming systems in each of the study districts, the Jinja Farming System (JFS) and Soroti Farming System (SFS), and explores the historical trends of these systems. Finally, it examines how such trends have influenced farming system adaptive capacity and discusses the implications for adaptation support.

Three major findings are noted from the two farming systems: (1) similar trends in system evolution have had differential impacts on the diversity of the farming systems; (2) trends have contributed to the erosion of informal social and cultural institutions and an increasing dependence on formal institutions; and (3) trade-offs between components of adaptive capacity are made at the farm-level, thus influencing overall farming system adaptive capacity. The findings provide insight into the dynamic nature of adaptive capacity and also enable the identification of factors that enable or constrain adaptive capacity at different levels. In particular, this chapter provides an important first step in understanding farm-level trade-offs and the resulting impacts on adaptive capacity across space and time. In practice, areas identified for further adaptation support include the need for: a shift away from one-size-fits-all approach to the identification and integration of appropriate modern farming method; a greater focus on building inclusive formal and

[4] This chapter is developed from a published journal article Dixon, J. L., Stringer, L. C., and Challinor, A. J., 2014. Farming System Evolution and Adaptive Capacity: Insights for Adaptation Support. *Resources,* 3**,** 182-214.

informal institutions; and a more nuanced understanding regarding the roles and decision-making processes of influential, but external, actors.

5.1 Introduction to Chapter 5

Studies of climate impacts on agriculture and adaptation often provide current or future assessments, ignoring the historical contexts within which farming systems are situated. Farming systems are an example of a complex and dynamic SES, and are therefore constantly evolving (see Section 1.3.1). Approaching farming systems as SES highlights that biophysical processes interact with human and management components to define the characteristics of the farming system (Keating and McCown, 2001).

Farming system adaptive capacity will shape the impacts of future climate change. Resources, institutions, productivity and diversity are all important components of farming system adaptive capacity (Section 2.12.1). Advancing the understanding of adaptive capacity as presented by Quinn et al. (2011) and Fraser et al. (2011) in Chapter 3, this chapter applies the integrated FSAC framework (Figure 2.2) to explore how trends in the evolution of the farming system from 1960 to 2012 have impacted upon adaptive capacity (Objective 1). The chapter pays attention to incremental changes in farming systems over time, as opposed to those associated with particular hazards. In doing so, it provides empirical evidence about both farming system evolution and the implications for farming system adaptive capacity. This provides the basis for the enabling and constraining factors identified in the discussion (Section 5.4). Such findings provide insight into how farming system adaptive capacity may be strengthened, thus identifying potential priority areas for adaptation support (Section 5.5).

5.2 Research design, methods and analysis

In this chapter, the systems approach outlined in Chapter 3, enabled the analysis of the interconnectedness and interdependence of components simultaneously influencing the JFS and the SFS, yet operating across time and space (e.g., climate, labour, markets, knowledge and so on). It further enabled farm households with similar characteristics and constraints to be grouped together, allowing analysis of the farming system. This provided a way to track how farming systems in the study areas have evolved over time (Objective 1).

The FSAC framework (Figure 2.2) brought together aspects of the work of Quinn et al. (2011) and Fraser et al. (2011). This chapter draws on all components of the FSAC framework as set out in Figure 2.2. In this chapter, the FSAC framework provides a way to organise and analyse primary empirical data in order to explore how trends in farming system evolution have influenced adaptive capacity (resources, institutions, productivity and diversity). Given a lack of information about appropriate weighting for these four components, they are assumed to be equally important in shaping farming system adaptive capacity.

Methods used to generate primary data include, household surveys, semi-structured interviews, focus-group discussions and observations (as outlined in Chapter 4). Farming system evolution from 1960 to 2012 was discussed during both semi-structured interviews and FGDs. During semi-structured interviews farmers recalled and discussed key changes in agriculture that have taken place in their lifetimes, the drivers of these changes, some of the impacts experienced and responses taken by farmers and other stakeholders. Although the length of memory and ability to recall events differed amongst individual interviewee respondents and FGD participants (cf. Marx et al., 2007, Simelton et al., 2013), key trends that fall within the desired time scales were identified and subsequently discussed.

A qualitative assessment of each trend and its impact on adaptive capacity was carried out using primary data from FGDs and semi-structured interviews to assess whether it had a positive or negative impact on farming system productivity, diversity, resources and informal/formal institutions (Table 5.2). For each trend, the associated impacts on adaptive capacity were quantitatively analysed. Each trend that was described as having a positive impact on each component, for example productivity, was given a score of 1. Those that were deemed to be negative received a score of -1. The number of positive and negative impacts relating to each farming system was summed to provide a basis for a quantitative analysis. A score of zero highlights that positive and negative impacts act to cancel each other out, rather than meaning that no impacts were recorded.

5.3 Results

Results are split into three sections. Firstly, Section 5.3.1 characterises current farming systems in the study districts, then Section 5.3.2 explores their evolution, whilst Section 5.3.3 examines the implications for farming system adaptive capacity.

5.3.1 Current farming systems

JFS and SFS are distinct in terms of the crop and livestock production, agronomic practices and the range of other livelihood opportunities being pursued to make up the farming system (for an overview of the JFS and SFS see Appendix 6). Both JFS and SFS are rain-fed farming systems with two growing seasons, though farmers in SFS tend to experience a distinct dry spell from November to February. In the JFS, farmers plant the same crops in the first and second seasons, whereas there is a distinction between first and second season crops in the SFS. Livestock also play an important role in the SFS, as productive resources used in cultivation, as well as providing a safety net, food, income and a means of resource accumulation. Visibly, the environments, topography, soils, tree species and coverage are different. Land tenure systems governing access, ownership and land use also vary and further distinction can be made in the way that agricultural products are sold or traded to generate food and income. Such findings highlight that the two farming systems differ in terms of the biophysical, social, economic and institutional context; such differences provide insight into our understanding of farming system adaptive capacity. These characteristics provide important current contextual background necessary to understand the evolution of farming systems and adaptive capacity (Objective 1).

5.3.2 How have farming systems evolved from 1960 to 2012?

Trends, the drivers of change and approximate timings of change identified by farmers in Soroti District and Jinja District are presented in a timeline format (Table 5.1). The timeline distinguishes between the farming systems during the 1960s–1980s and then from the 1990s-2012. Many of the key changes happened during and since the 1990s, leading to farmers distinguishing between 'then' and 'now'. This distinction also coincides with other political events, for example, Uganda gaining independence in 1962, and the beginning of President Museveni's term in office in 1986.

Similar trends in farming system evolution are found in both the SFS and JFS (Table 5.1). In both systems, the major trend farmers discussed was the shift from traditional to modern farming methods, including: changes in the crops cultivated; an increase in the cultivation of new varieties; increase cultivation in swamps; an increase in selling food crops; and an increase in off-farm activities. Despite these similarities, the details in terms of which crops and which practices have changed are specific to the farming system (Table 5.1).

In both farming systems, other natural resources, for example trees, wetlands and indigenous forests, have been drawn upon as coping mechanisms in difficult periods by providing a source of food and medicine. Forest products, for example timber, have also been used to generate income to support the recovery of livelihoods following a range of hazards and to provide financial support for agricultural activities and rural livelihoods more broadly. Additionally, in the SFS, farmers identified a trend of cutting down trees after periods of political instability (1986–1992 and 2003–2004) and selling timber to generate income. This coping strategy, undertaken in both farming systems, has become a 'normal' practice to cope with on-going seasonality and stresses, resulting in localised natural resource degradation.

It is also important to note two key trends that emerged as being unique to each farming system: fluctuations in livestock numbers (SFS) and decline in the interest in agriculture (JFS). Instability experienced in SFS during 1980s resulted in declining livestock numbers, but as people rebuild their livelihoods, livestock numbers have been subsequently increasing. As a farmer in Soroti explained:

> *"first of all the cows have reduced the Karamajongs (ethnic group in Uganda) took away the cattle and people remained poor and they used to cultivate using hand hoes… then people started buying chickens, then they moved on buying goats, then they reach a level of being able to buy cows and bulls. That is now why you see that people are beginning to have a few livestock around."*

(Male Respondent, Adamasiko, Soroti District, April 2012.)

Table 5.1 Key trends in the evolution of the Soroti Farming System (SFS) and Jinja Farming System (JFS) from 1960 to 2012. Data compiled from focus group discussions (FGDs) and semi-structured interviews (SSIs).

Soroti Farming System				
Trends	**Description of trend**	**Farming system from 1960s to 1980s**	**Drivers of Change**	**Farming systems from 1990s to 2012**
Shift in farming methods	A shift from traditional farming methods to modern farming methods. Increase in use of hand hoes for ploughing.	Traditional methods, including: broadcasting seeds; oxen for ploughing; saving seeds; planting traditional crop varieties.	NGO programmes Government policies Political Instability Increases in theft	Integration of modern farming, including: planting in rows and spacing crops; using improved seeds; application of fertilizers/pesticides.
Shift in crops and varieties under cultivation	Decline in cotton and millet production. Increase in cassava and maize production. Cultivation of new crops not traditionally grown in the Teso sub-region. Introduction of new crop varieties, e.g. short maturing varieties.	Main food crops under cultivation: millet, peas, groundnuts, sorghum, sweet potatoes. Main cash crops under cultivation: cotton. Cultivation of mostly local varieties. Seeds for cash crops provided by government initiatives and cooperatives. Widespread practice of seed saving.	NGO programmes Government policies Increase in weeds and crop diseases New market opportunities Changing farmer preferences Land fragmentation Changes in weather Market price fluctuations	Main crops under cultivation: cassava, sweet potatoes, groundnuts, sorghum, some millet and peas. New crops: maize, rice, sugarcane, beans, vegetables, tomatoes. Combination of both local and improved varieties. Some evidence of seed saving.
Increase in food crop production specifically for market	Increase in cultivation of food crops for market. Farmers selling traditional food crops to generate income, for example cassava, sorghum and millet.	Distinction between food and cash crops. Food crops saved and stored for eating and home use. Cash crops sold to market, some through cooperatives.	New market opportunities Increased demand for financial resources Market price fluctuations	Food crops are grown for home consumption and to generate income. All crops sold through markets.

Cultivation in wetlands	Farmers cultivating new crop varieties, e.g., rice, in swamp areas.	Wetlands and swamp areas uncultivated and generally used as communal grazing land.	NGO programmes Government policies Changes in weather Increases in population Land fragmentation New market opportunities	Cultivation in swamps, especially new crop varieties (sugarcane, vegetables, rice).
Using natural resources to generate income and support farm activities	Evidence of clearing forests, cutting trees, charcoal burning, brick making, *etc.* Income used to meet household needs and invest in agriculture.	Natural resources used as a source of food and medicine and as coping strategy for various shocks and stresses.	Political instability New market opportunities Increased demand for financial resources	Natural resources as a source food, medicine. Natural resources used to generate income.
Increase in off-farm activities	Farmers are pursuing off-farm livelihood activities to generate income.	Dependence on livestock and crops. Off-farm activities used as a coping strategy to multiple shocks and stresses.	Political instability Decline in livestock numbers Increase in off-farm opportunities Increased demand for financial resources	Range of livelihood strategies being pursued. Livestock numbers are recovering. Off-farm activities used as a coping strategy to multiple shocks and stresses.

Fluctuations in livestock numbers	Livestock numbers declined following political instability 1986–1992. As livestock numbers were recovering another period of instability in 2003 affected numbers. Since then, livestock numbers are slowly increasing.	Farming systems based upon the integration of livestock and crops. Livestock used as a productive asset, as well as providing a means of providing a safety net, accumulating farm resources and generating income. Communal and marginal lands, especially bordering swamps, as designated grazing lands.	Political instability Increases in population Land fragmentation New market opportunities New crops and varieties	Livestock numbers increasing since 2005. Farmers prefer to own and use livestock, especially oxen, as a productive asset. Livestock also provide a safety net, allow resource accumulation and generate income. Less communal/marginal lands available for grazing.
		Jinja Farming System		
Shift in farming methods	Shift from traditional farming methods to modern farming methods. Farmers no longer use traditional granaries to store large quantities of food; instead sacks inside homes are used. The need for money, market opportunities, and buying seeds each season has eroded traditional storing practices.	Traditional methods include: saving seeds; planting traditional varieties.	NGO programmes Government policies Increases in theft New market opportunities Land fragmentation Changes in land use	Shift to modern farming methods, including: Planting in rows and spacing crops; using improved seeds; application of fertilizers/pesticides. Reduction in the amount of land cultivated for food crops.

Shifts in crops and varieties under cultivation	Cultivation of cotton has declined since 1960. Cassava and groundnut production are declining. Coffee was introduced in 1970s but is now in decline. Areas of banana plantations are also declining. Maize and sugarcane production has been increasing since 1990s. New crops and improved varieties are now under cultivation, for example rice and vegetables.	Main food crops: sweet potatoes, cassava, groundnut, beans and maize. Main cash crops: cotton then coffee and cocoa. Mostly local varieties under cultivation. Seeds for cash crops provided by government initiatives and cooperatives. Widespread practice of seed saving and storing food.	NGO programmes Government policies Decline in cooperatives Increase in crop diseases New market opportunities Land fragmentation Changes in weather	Main crops: maize, beans. New crops: rice, sugarcane, and vegetables, e.g., tomatoes, cabbages. Combination of both local and improved varieties. Some local varieties have almost disappeared, e.g., maize and groundnut. Reduction in the amount of land cultivated for food crops. Increasing sugarcane cultivation, includes selling off land, renting land out and planting on own land.
Increase in food crop production specifically for market	Farmers are selling traditional food crops, for example maize. Farmers growing food crops, e.g., vegetables, specifically for generating income.	Distinction between food and cash crops. Food crops saved and stored for eating and home use. Cash crops sold to market, some through cooperatives.	New market opportunities Increased demand for financial resources	Food crops are grown for home consumption and to generate income.
Cultivating in swamps	Farmers cultivating new crops, for example rice, in swamp areas.	Swampy areas not used for cultivation.	Government policies Changes in weather Increase in pests, e.g., moles Increases in population Land fragmentation Changes in land use	Cultivation in swamps, especially new crop varieties (vegetables, rice) and sweet potatoes to avoid pests.

Increase in off-farm activities	Farmers are pursuing off-farm livelihood activities to generate income.	Dependence on crops as a source of livelihood. Off-farm activities used as a coping strategy to multiple shocks and stresses.	Increase in off-farm opportunities Increased levels of education Increased demand for financial resources	Range of livelihood strategies being pursued. Off-farm activities used as a main livelihood strategy, especially amongst men.
Using natural resources to generate income (including deforestation)	People involved in charcoal making, brick making, selling trees, timbers to generate income. Supplementary income used to support household needs, e.g. school fees, rather than invest in agriculture. Areas of indigenous forest have been cut and replanted with high value non-indigenous trees, for example pine. Trees and forests have been cleared for crop production, and to provide additional income generating activities.	Large areas of indigenous forests. Natural resources largely used for home consumption, e.g., firewood rather than to generate income. Evidence of indigenous forest. Trees and forests used as a source of food and medicine and as coping strategy for recovering from various shocks and stresses. Trees provide shade for coffee and banana plantations.	Increase in market opportunities Increased demand for financial resources Multiple pressures affecting yields Government forestry policy New market opportunities Increased sugarcane production Increased demand for financial resources.	Loss of indigenous forests since 1990s. Natural resources, especially trees have utilized to generate income. Such activities are now reducing due to natural resource degradation. Indigenous forest has disappeared and replaced with pine tree species. Fewer trees, though they are a source of food, medicine and income. Less diversity of tree species.
Decline in interest in agriculture	Men, especially educated youth, are increasingly seeking off-farm income generating opportunities, including casual work locally or migration to towns. Education levels, aspirations and preferences have changed; agriculture is perceived as ‘drudgery’.	Mostly family labour used on farm. Some off-farm activities.	Increased levels of education Increases in off-farm opportunities Changing preferences and aspirations amongst the youth	Higher levels of off-farm migration—urban areas and sugarcane plantations. Decline in available farm labour and an increasing burden on women.

In SFS, cattle have traditionally been a key feature of the farming system, despite the fluctuations in livestock numbers. This is not the case in the JFS, where the cultural and production practices differ, farmers have no access to communal grazing lands and currently, most land is cultivated with crops.

In both areas, men, especially educated youth, are increasingly seeking off-farm income generating opportunities. In JFS this includes: finding casual work locally on sugarcane plantations; gambling by playing cards or other games in local trading centres; and migration to nearby urban centres to seek employment opportunities. An emerging theme in JFS was the changing attitudes towards farming as a desirable livelihood option resulting in the decline in labour available. Although off-farm income generating opportunities are undertaken in SFS, they are not changing attitudes towards agriculture. In JFS farmers noted that as more children are going to school and people become exposed to urban life, their aspirations and preferences have changed; agriculture is now perceived as 'drudgery'.

> *"There is a shortage of labour in this area now, because of these children going to school… Everybody is at school and you find people of our ages, we don't have enough energy… Also young people today do not want to go to the garden. They want to go to school, then town, get good jobs, [which makes] coming back to the village a problem."*

(Male Respondent, Bituli, Jinja District May 2012).

Although similar trends were identified by farmers in both areas, the drivers of change and the interactions between these drivers differed. To add further complexity, the data also show that some of the trends are connected. Farmers in Soroti, for example, linked planting in wetlands to the cultivation of new crops and new market opportunities, e.g., rice, which requires more water than traditional crops. Similarly, in the JFS, the decline in food storage is linked to an increase in the sale of food crops, which farmers then linked to the type of crops and varieties grown at the farm level and the market opportunities available. During a FGD, farmers in one village explained:

> *"I remember the time when I came here, we would get food and we would not sell any [food]."*

(Female Participant, Kalugu, Jinja District, May 2012).

> *"Because of the higher price of maize, it has made people not keep maize, but in those days maize was at 100 shillings ($0.04) a kilo, now it is 1000 shillings ($0.4) a kilo and people really want to receive that money. So saving sometimes to keep maize is a problem "*

(Female Respondent, Kalugu, Jinja District, May 2012).

Single drivers are also linked to multiple trends. In SFS, for example, when government policies and programmes are isolated as a single factor, they interact with other variables across time and space. For example, they also interact with NGO programmes, markets, and demographic shifts, to result in multiple outcomes: planting new varieties; cultivating in swamps; applying chemical inputs; and an increase in the selling of food crops. Despite the apparent similarities amongst the trends, the specific interactions, connections and context differ at the farming system level, thus suggesting trends have had differential impacts on farming system adaptive capacity.

5.3.3 What are the impacts of historical trends on farming system adaptive capacity?

Overall trends, including the shift from traditional to modern farming, have had a positive influence on the productivity and diversity of the SFS. In the JFS they have had an overall neutral effect on productivity, but have negatively impacted upon diversity. Furthermore, the same trends have had an overall positive impact on resources in the SFS, whilst negatively impacting upon the JFS. The biggest similarity between trends is the collective impact they have had on informal or formal institutions, where there is a negative effect in both the JFS and SFS. The biggest difference is how the trends have impacted upon diversity, where there is currently less diversity in terms of crops, livestock, and income generating activities in the JFS. To further explore some of the reasons for these differences each of the components is considered separately.

Table 5.2 The impact of trends in farming system evolution on the adaptive capacity of the Soroti Farming System (SFS) and Jinja Farming System (JFS). Impacts with a '+' are deemed to be positive and those with a '–', negative, those with no sign are neutral. Impacts experienced in both farming systems highlighted in bold, those related to SFS are in italics and JFS underlined.

Trend:	Productivity	Diversity	Resources	Informal and formal institutions
Shift from traditional to modern farming—including: **(1) Shifts in farming methods** **(2) Shifts in crops and varieties** **(3) Increase in selling food crops**	**+Maintaining productivity of farming system** **+Opening previously unproductive land** +Promoted as an intensive farming practice in response to multiple land and soil pressures to maintain productivity *+Facilitated the recovery of farming systems following instability and civil unrest* **–Mixed results on increasing productivity** **Dependent on weather, access to knowledge and inputs**	*+Evidence that it is increasing the diversity of crops and varieties under cultivation* *+Maintaining diversity—evidence of farmers planting a combination of 'improved' and traditional varieties* *–Some evidence of mono-cropping* –Widespread evidence of mono-cropping specific crops, e.g., sugarcane –Widespread evidence of mono-cropping of certain varieties, maize and groundnut –Loss of traditional varieties, e.g., maize and groundnut	+**Maintaining source of food and income** ** **+Crops, e.g., sugarcane and cassava, require less inputs: time, labour and management** **+Providing income as a safety net, and resources to meet farm-level demands and development** *+Reduces 'wasted' seeds* *+Provided income for recovery from instability and civil unrest fostering accumulation of productive assets e.g., livestock* *+Evidence of farmers gaining knowledge through planting mix of traditional and improved varieties* **–Some crops, e.g., vegetables, require more inputs: time, labour** **–Group membership and/or money are required to access training and inputs** **–Decline in seed saving**	**+Strengthening village social networks through groups membership** * **+Farmers accessing new markets** **+Increases in income are allowing farmers to form saving schemes (e.g., Village Savings and Loan Associations—VSLAs)** **–Requirement of group membership excludes some farmers** * **–Farmers becoming dependent on external assistance—e.g., NGO assistance and markets** **–Reducing traditional seed saving practices** *–Eroding traditional practice of celebrating harvests by sharing with others in village, e.g., millet*

Trend:	Productivity	Diversity	Resources	Informal and formal institutions
Increase in off-farm activities	**+Potential indirect impact on maintaining productivity through generating income **** **+Coping strategy used to respond to low yields, food shortages etc.** **–Indirect impact on productivity by reducing labour available**	**+Diversifying livelihoods, less dependent on agriculture**	**+Income generating **** **–Increasing need for resources to hire labour to due reduced availability of farm labour**	**–Influence on family as a social institution** –<u>Indicator of changing aspirations of rural youth</u>
Changes in the utilisation of other natural resources, including planting in wetlands	**+maintains productivity of farming system** *+enabled recovery of the farming system following instability and civil unrest* **–Indirect impact on productivity: reducing trees influencing weather patterns and growing seasons** <u>–Reduced shade, resulting in negative impact yields, e.g., coffee</u>	**–Reduction in biodiversity**	**+Income generating **** **–Leading to natural resource degradation** **–Evidence of natural resource degradation, e.g., swamps and soils** *–Increases in flooding/water logging of low-lying areas*	**–Erosion of a traditional natural resource based coping mechanisms**
Fluctuations in livestock numbers	*–Indirect impact on productivity by affecting productive resources and the size of land under cultivation*	*+Preference for and integration of livestock adds to the diversity of the farming system*	*+Provides organic manure used as fertiliser* *-It is taking time for livestock numbers to recover, some farmers have no access* *+ and – Impacts upon the farm-level time, labour and resources needed for cultivation*	*+Farmers can hire, trade and share livestock, strengthening social networks* *-Currently creating a distinction between those that have and those that do not*

Trend:	**Productivity**	**Diversity**	**Resources**	**Informal and formal institutions**
Decline in interest in agriculture	−Indirect impact on productivity by reducing labour available	+Diversifying farm livelihoods, less dependent on agriculture	+Income generating ** −Labour Shortage	−Migration influencing family as a social institution

* Group membership is a requirement of both NGO programmes and government agricultural research and extension services; ** Evidence that increased household income does not translate into food or livelihood security; it depends on farm-level decision making processes and the access to and control over resources.

5.3.3.1 Productivity

In both farming systems productivity has been maintained. The qualitative data presented does not allow any claims to be made about specific crop or livestock production (Table 5.2). A lack of sub-national crop and livestock productivity data made it difficult to conduct quantitative analysis. Instead, the qualitative data provide an insight into some of the factors influencing productivity, for example labour, income, weather and in the case of the SFS, political instability.

Productivity in the SFS has been maintained through the use of natural resources and increases in off-farm income generating activities. These coping strategies enabled farming system recovery following periods of instability and civil unrest, thus confirming that natural resources are drawn upon to meet short term needs when socioeconomic resources and the institutional capacity to support farmers are limited (see also Fraser and Stringer, 2009). However, in the JFS the decline in interest in agriculture, especially amongst the youth, has had negative impacts on productivity by reducing the availability of labour. Furthermore, in JFS, natural resource utilisation has led to deforestation and degradation, and is negatively impacting upon production of specific crops, for example coffee. Positive impacts on JFS stem from the introduction of new crops and varieties that have maintained farming system productivity in the face of multiple pressures. However, overall, these trends combined have limited the productivity of the JFS.

The interconnectedness of issues over time and space, and how they have shaped current farming system productivity, are illuminated in Case Study 1 (Box 1), which was compiled from a semi-structured interview in Phase I.

Box 1 Case Study 1: Fred, Male Farmer, Idoome Village, Jinja District

Fred, 56, was born in Idoome Village, after his father moved there from a neighbouring district (Kamuli) before he was born. When Fred was growing up, he remembers very few people living in the area and large forested areas. Over the years he has seen many changes, including: clearing of forests; increases in population; new pests affecting crops, changes in weather; and an increase in sugarcane cultivation. In terms of agriculture, Fred recalls, *"the change that is there is that farming is a business, but the bad thing is that we don't get the yields that we used to get before. The quantity that we used to get before was high in those days"*.

Fred started by cultivating coffee and banana plantations to generate household income. However, changes in the weather, increases in pests and diseases, and declining coffee prices mean that the environmental and market conditions no longer support banana and coffee production. As a response to these changing conditions, Fred has started cultivating a range of vegetables, including tomatoes, aubergine and cabbages in nearby swamps as this reduces the risks posed by certain pests (moles) and changes in the weather. He also has a field of maize that his wife is responsible for maintaining. All of Fred's sons have moved away to study or seek casual work in nearby trading centres – they aren't interested in agriculture and see it as 'drudgery'.

Once crops are harvested, they are sold through middlemen, who come to the area on bicycles or trucks to buy up certain commodities. Fred depends on the prices that they offer him, but complains that because he has to sell his crops straight away after harvest, the prices he is offered are low. Crops are sold straight away to generate income to meet household needs, including food, school fees, healthcare and agricultural inputs. Because Fred grows improved crop varieties, he must also buy a range of chemical inputs or he risks low yields in the future. Heavy rain in recent years has caused localized flooding, affecting the vegetable crop yields. He is aware that this may be a problem in the future and that using chemicals may have long-term consequences, but feels that he has few other options, given the shortage of land in the area.

In addition to farming, Fred also looks for casual work on nearby sugarcane plantations. Unlike other households in the area, Fred has resisted growing sugarcane on his own land. He describes sugarcane as an 'easy' crop, i.e. it generates money and at the same time is resistant to pests and diseases, changes in weather, and doesn't require much time, labour or inputs. However, he sees the increase in sugarcane production as creating problems for food production, *"the land is small and it is not fertile. Even those people with large chunks of land have planted sugarcane. So depending on that the supply of food will be very small".*

Fred hopes that by diversifying into other non-agricultural activities he can build a permanent house with bricks and a tin roof and send his children through education. At the same time, he is concerned about the number of 'famines' that they are experiencing as a family.

5.3.3.2 Diversity

The biggest differences between individual trends analysed in Table 5.2 is how they have impacted on the diversity of the farming systems. In the case of the shift to modern farming, all of the impacts on diversity are underlined or in italics (Table 5.2), highlighting a difference between the impacts in the different systems. Overall, trends have had more positive impacts on the diversity of SFS, but negative impacts on the JFS. These differences can be explained through the adoption of modern farming practices: in the case of SFS there is evidence that such methods have been integrated into the traditional system rather than replacing it, thus maintaining a certain level of diversity. This can also be explained by the management practices employed at the farm-level, both in terms of specific crop varieties and livestock breeds, and the extent to which the introduction of modern farming has led to the loss of traditional varieties and breeds. Evidence suggests that traditional varieties of some crops (specifically maize and groundnuts) are diminishing or have been lost altogether in JFS. Two farmers in JFS explained:

> *"the traditional ones are diminishing, now we don't have traditional maize or groundnuts, they're not there."*

(Male Respondent, Bituli, Jinja District May 2012).

> *"the other local variety no longer yields well, so we changed to this improved one which can yield at least ."*

(Male Participant, Idoome, Jinja District May 2012).

Modern farming, particularly in the form of new seed varieties, was presented by farmers in Jinja District as the only solution to the multiple and pressing challenges they are facing. However, in Soroti District, opinions are mixed and there is more evidence of an integrated approach, whereby farmers are growing a combination of crops and varieties. Farmers in Soroti District described both positive and negative opinions about modern farming, and 'improved' crop and livestock breeds in particular. How improved crop varieties were received by farmers depended firstly on the crop:

> *"take the example of groundnuts, the improved ones have proved to be good, but some have proved to be not good. We have serenut2- that one is doing well, but we have Serenut 3 and Serenut 4 (Serenut2, 3, 4 are improved varieties of groundnut), but they have failed"*

(Male Respondent, Adamasiko , Soroti District, April 2012.)

Secondly, it depended on access to the other inputs necessary to obtain better yields:

> *"it's not the same because the improved ones, if you don't spray you don't get anything, but these local ones can, you are sure you can still get something, even if the weather is bad and you don't spray you can get something."*

(Male Respondent, Adamasiko , Soroti District, April 2012.)

Nonetheless, the range of opinions in Soroti District is distinct from the narrower range of perceptions of the farmers in Jinja District where improved varieties are seen as essential and desirable, and the use of traditional varieties has declined. Case Study 2 (Box 2) highlights some of the factors that have influenced the diversity at an individual farm system level.

Box 2 Case Study 2: Joyce, Female farmer, Kangeta Village, Soroti District.

Joyce has been a farmer in Kangeta since 1980. She was born in a neighbouring village and moved to Kangeta when she was married at the age of 20. She has 7 children, some of whom live in the homestead alongside her grandchildren. Her husband died recently, so she is now the head of the household. Labour is a significant limiting factor to how much she can produce.

If Joyce produces excess, then she tries to store and save seeds in traditional granaries, this means that she knows she can eat through the dry season and have seeds to plant the next season, which enables her to cultivate a variety of crops each season. If the rains are delayed or she doesn't have enough food, then she also cultivates and dries leafy green vegetables. But she explains that traditional practices of storing seeds are declining because *"these days everything is marketable. Everything that people grow has a market, so people can't keep those seeds. Whenever he or she gets, they decide to sell just to get cash for things like school".*

Following political instability during the 1990s and recent flooding, Joyce has received support from government agricultural extension services and NGOs in the form of groundnut seeds, cassava cuttings and training. Influenced by this, Joyce now cultivates a range of different varieties of the same crop, although she is critical of some of this support. For example, some of the improved crop varieties don't yield well, she doesn't like to eat others and others are not suitable for the local markets where she sells any excess crops. Joyce also describes how some of the new varieties require chemical inputs, such as pesticides and fertilisers, in order to yield well. Joyce rarely has the money to buy such inputs and she also thinks that the traditional can better withstand the environmental conditions without money.

Currently, Joyce prefers to grow a mix of crops and varieties, including both a mix of traditional and improved varieties to spread the risks associated with uncertain growing and market conditions.

5.3.3.3 Resources

The main resources considered were: human (time, labour), natural and financial resources (Table 5.2). Although these resources cross spatial scales, the predominant focus was within the farming system. This means, for example, nearby forest reserves were excluded, but forests, swamps and wetlands that farmers utilise are included.

Data highlight differential impacts on resources, depending on the nature of the resource. However, collectively there was no overall positive impact on resources in the SFS, yet more negative impacts were noted in the case of the JFS, especially on the natural resource base. Data suggest that changes in land, forest and wetland management have resulted in environmental degradation, including loss of habitats and loss of non-crop diversity. Although the negative impacts upon the resource base may not be urgent problems at present, they could negatively influence future adaptive capacity. For example, although planting in low-lying wetlands helped to maintain productivity during dry spells, farmers in SFS suggest that heavier rainfall and processes of silting have increased water-logging and localised flooding in surrounding areas. Positive impacts on farm-level financial resources were recorded in both farming systems, related to ability of the system to generate income. However, in some cases, more resources (human, financial) were needed to generate this income.

Comparing the results from both farming systems in this section is inconclusive as the actual impacts on the farming system depend on the crops grown and their management at the farm-level. For example, as highlighted in Case Study 1 (Box 1), sugarcane cultivation in JFS consumes less time, labour and fewer on-going financial farm-level resources; whereas vegetable crops in both farming systems require more time, labour and management. Although both of these trends potentially increase household incomes, they have also increased the need for other farm-level resources (time, labour), or have had negative impacts on the natural resource base. Because they are mostly market-based crops, they have further contributed to eroding traditional coping mechanisms, such as drying and storing food. This complexity and interconnectedness highlights that trade-offs between resources, and therefore elements of adaptive capacity, occur at the farm-level. Some of these issues are highlighted in Case Study 2 (Box 2), which also demonstrates both the complexity and importance of farm-level decisions.

5.3.3.4 Informal and formal institutions

Out of all of the components of adaptive capacity, the most similarity between the SFS and JFS was in the impacts of trends on formal and informal institutions, where analysis shows few positive impacts (Table 5.2).

Formal institutions, such as government policies and programmes have eroded some informal institutions. For example, in SFS policies and programmes promoting the commercialisation of agriculture, increased market opportunities and the subsequent selling of food crops are eroding traditional cultural practices of celebrating harvests by sharing millet, drinking locally made brew and roasting meat with community members. In JFS, the increase in off-farm activities and migration, driven by labour market opportunities, is influencing the family as an informal institution.

Formal institutions have also had positive impacts on informal institutions, for example there are positive impacts associated with increased group membership, accessing new markets and the formation of saving schemes. However, the requirement to be part of a group to access extension services limits access to certain knowledge and technologies and is excluding some community members. Within a district or village, the way that the formal institutions play out results in winners and losers. During an interview, a female farmer from Soroti District explained:

> *"Some have improved [seeds], some have local [seeds]. Those who are able to get the improved ones are those people who are in groups. NGOs when they come they don't give to individuals, they give to groups, so you find those groups at least have improved varieties and those who are not in groups grow local."*

(Female Respondent, Kangeta, Soroti District, April 2012.)

Simultaneously, trends are also increasing the dependence on external institutions such as markets, NGOs and government. Farmers expect agricultural inputs, including seeds and new breeds from external organisations. These may have positive impacts for a few farmers in the short term in terms of maintaining productivity. However, from the data it is unclear how they impact upon farmers who are excluded or what impacts they will have in the long term, and thus how they will shape future farming system adaptive capacity. Some of these challenges are illustrated from data compiled with interviews with farmers and policy makers in Jinja District in Case Study 3 (Box 3).As highlighted in Case Study 3, how governments and NGOs make decisions about what types of seeds, inputs, and advice to promote is unclear.

Box 3 Case Study 3: Agricultural policies and programmes in Jinja District

Numerous government agricultural programmes have been delivered through agricultural extension officers in Jinja District. These programmes range from the provision of inputs, such as seeds and livestock, and capacity building and training. Additionally, non-government organisations (NGOs) are also operating in villages to provide training on post-harvest handling, storage, processing and marketing. Farmers said that both the government and NGOs promote modern agriculture through the provision of both inputs and training. Over time, this has shaped the types of varieties that farmers are cultivating and inputs. In the short term NGOs and government extension officers described potential yield and income benefits, but some interviewees were concerned that they did not always address farmers needs and questioned the environmental sustainability of some of the agricultural programmes.

Farmers listed a number of benefits associated with receiving agricultural support, for example improving yields, increased income. However, they also raised a number of complaints. Firstly, some of the inputs provided do not always yield positive result, especially if particular management practices are not followed, for example weeding, application of fertilisers and pesticides. These practices are expensive for farmers to maintain over time. Additionally, a number of complaints were made during interview about how few farmers actually benefit from both government and NGO agricultural programmes. To benefit from agricultural support and access these benefits, farmers need to be part of a registered group. Not all farmers are part of groups, as they require time, existing resources, and commitment. This is creating winners and losers within a village, where only the active farmers, who already have money and resources, actually benefit from the groups. When these issues were discussed with agricultural extension officers, they outlined the process for selecting individuals and groups was decided at the village level, and was therefore influenced by village level politics.

Agricultural extension officers also discussed how they made decisions about what types of agricultural support to provide. Government agricultural extension is influenced by existing national policies and priorities, and emerging risks, for example pests and diseases such as banana wilt. At the same time, individuals and groups are increasingly given decision-making on inputs.

5.4 Discussion

Figure 5.1 was compiled from the results presented in Table 5.2 to illustrate how the historical trends have influenced the components of adaptive capacity. It demonstrates that when the impacts of the trends are analysed collectively, there have been overall positive impacts on the SFS, and overall negative impacts on the adaptive capacity of the JFS. The biggest difference between the JFS and SFS is in how the shift from traditional to modern farming has impacted upon the adaptive capacity of the farming system, highlighting that the farming systems have had different experiences of shifting towards modern farming methods. In JFS, such methods have largely replaced traditional farming practices, crop varieties and methods, whereas in SFS they have been integrated into traditional practices.

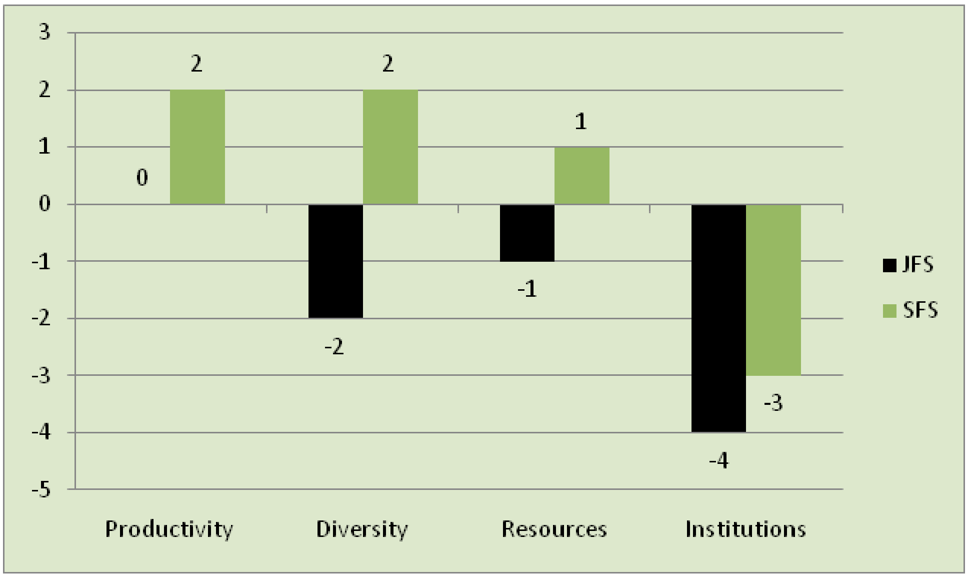


Figure 5.1 An illustration of the historical trends and their impacts on the components of adaptive capacity scores are derived from Table 5.2. Findings for the Jinja Farming System (JFS) are in black and Soroti Farming System (SFS) in green.

Through the data presented in this chapter, various factors that enable or constrain adaptive capacity can be identified. This discussion reflects on some of the factors and the implications of the findings for future research, providing insight into specific interventions needed to strengthen adaptive capacity both in the study districts and in farming systems more broadly. It also identifies some areas for further research, and where specific action is needed to build adaptive capacity as a means to maintain and strengthen farming system resilience and reduce vulnerability.

5.4.1 Enabling factors

High levels of diversity have been maintained in the SFS, by adding and integrating modern farming methods rather than replacing traditional methods. Although it is unclear whether this is an intentional approach adopted by farmers, government research and extension workers or NGO programmes, it suggests that as 'modern' varieties of crops and livestock are introduced, traditional production systems and associated local breeds are marginalised. Subsequently, this leads to a loss of genetic and cultural diversity in both crops and livestock (Thornton et al., 2009b), as in the case of the JFS. Yet maintaining diversity will be important in fostering future farming system adaptive capacity.

Findings demonstrate that formal institutions, for example government policies, extension services and NGO programmes influence farming system adaptive capacity by shaping on-farm decisions. In the case of the JFS, evidence suggests that this is having a negative impact upon farming system adaptive capacity. Policies are contingent on historical pathways and can be difficult to change (Wise et al., 2014), therefore government research and extension services and NGO programmes should think critically about the extent to which their approaches are enhancing or undermining adaptive capacity. There is potential to use the FSAC framework (Figure 2.2) to assess the potential impacts of policies or programmes during the design process. For example by using system properties to guide monitoring and evaluation. Alternatively, there is potential to use the same part of framework to understand the impacts of existing policies and programmes.

Data presented here reinforce the view that farmers have changed their agricultural practices and livelihood strategies in response to a range of pressures and opportunities (Thomas et al., 2007). Adaptation to climate change will, therefore, not take place in isolation (Adger et al., 2005c). Many management decisions and resource allocations, influenced by multiple factors operating across spatial scales, are made at the household level. This confirms that farmers, who make these management decisions, influence the impacts of future changes (Twyman et al., 2011). However, farmers do not operate in a vacuum, and the decisions they make are based largely on outside influences (Darnhofer et al., 2010). Such decisions further influence farm-level adaptive capacity, and therefore contribute to the farming system adaptive capacity. Future analysis of farming systems should recognise farm-level decision-making as crucial to determining adaptive capacity

(Quinn et al., 2011). There is a need to understand how farm management and resource allocation decisions are made, how such decisions shape adaptive capacity and ultimately, the vulnerability and resilience of farming system. On-farm trade-offs and how they impact on adaptive capacity also need to be explored fully; presenting data collectively at the farming system level can mask variations between individual farms.

5.4.2 Constraining factors

A sole focus on productivity in the short term discounts the importance of fostering future adaptive capacity, which also includes maintaining long term productive capacity. Moreover, national and international agricultural research need to shift the focus from the short to longer term. There needs to be a balance between short term projects, which are often narrowly focused on productivity, and long term research which seeks to strengthen all adaptive capacity components.

Despite overall trends having had a positive impact on the adaptive capacity of the SFS other weaknesses in the farming system still exist. Whilst productivity, diversity and farm-level resources have been maintained in the SFS, there is inconclusive evidence about the extent to which the SFS has been able to grow and develop, thus raising important questions about resilience, development and poverty reduction (Béné et al., 2014) and the synergies and trade-offs between them. For example, compared with Jinja District, Soroti District has much higher poverty levels and ranks lower in terms of socioeconomic development in multiple ratings (Emwanu et al., 2003, Rogers et al., 2006, UBOS, 2009). The evidence on the extent to which farming systems with high levels of adaptive capacity are able to maximise productivity and increase incomes is inconclusive, highlighting additional areas for future research. This also raises important questions about trade-offs between short term socio-economic development and productivity with enhancing overall adaptive capacity, including productivity, in the long term (Heltberg et al., 2009). These issues warrant further investigation.

Some issues, for example, the decline of informal insitutions, can be found in both farming systems, suggesting that some common actions are needed to enhance this component of farming system adaptive capacity. This highlights how the vertical interplay between formal and informal institutions (Young, 2006, Young, 2002) can shape adaptive capacity. Moreover, this interplay results in winners and losers within the farming system, which can exclude particular farmers and thus potentially reinforce existing power structures (Friis-Hansen et al., 2004). For example, farmers described how current agricultural policies and

NGO programmes, an example of a formal institution, are selecting particular individual or groups and that there is a politics behind the selection process. This results in uneven impacts and distribution of resources, which is susceptible to elite capture:

> *"those people [agriculture officers] when they come on ground they only choose a few people and others are left out. Like the time they brought groundnut seeds, only one person got it...we are also expecting women to also get beans, but it has not reached, it is affecting us"*

(Male Respondent, Bukolokoti, Jinja District, 2012).

This chapter has provided insight into complexity of institutional dimensions of farming systems and how they influence interactions between resources and institutions, ('system inputs' in Figure 2.2). Decision-making should be included as a system input as an important component of adaptive capacity (Figure 5.2). In recognition of this, future work should emphasise the importance of decision-making in shaping farming system adaptive capacity, thus calling for the consideration of decision-making and decision-making processes and their role in shaping how system inputs are used to shape the characteristics of farming systems. Moreover, this thesis demonstrates the important influence of the decisions of influential, but external, actors, such as government, suggesting that the decision-making and implementation processes of both governments and NGOs at the national and sub-national level require further study. In practice, more emphasis is needed on fostering inclusive institutions.

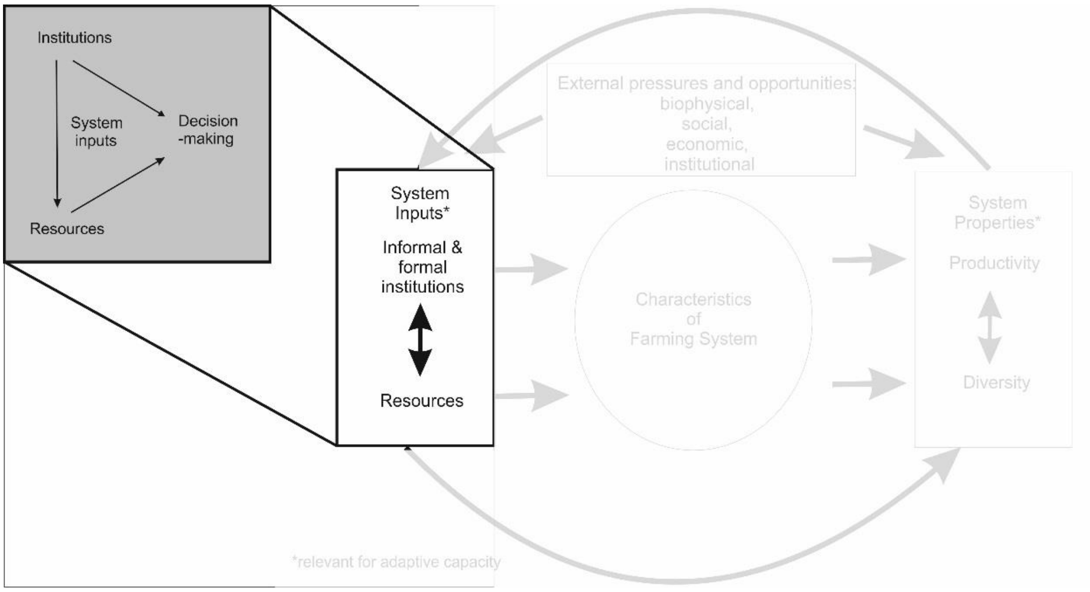


Figure 5.2 Illustration of how the 'system inputs' component of the Farming System Adaptive Capacity framework (Figure 2.2) has been advanced. Modification is highlighted in grey.

5.5 Implications for future adaptation support

Given that multiple drivers operating across spatial scales were identified as driving trends in farming system evolution (Table 5.1), this research supports the view that climate change *"is nested in among existing climatic conditions and numerous more proximal and pressing concerns"* (Rickards et al., 2011:2). This perspective usefully highlights the contextual nature of farming systems.

There is potential to learn from the experiences in Soroti District and Jinja District to promote strategies that enhance overall adaptive capacity, thus reducing vulnerability and strengthening resilience. There are some unique challenges specifc to the JFS and the SFS, for example the changing attitudes of youth in JFS and the role of livestock in the case of SFS, demonstrating that context specific actions will be needed. More broadly this highlights that the historical and contextual nature of farming systems is important, therefore policy and practice should move away from a one-size fits all approach. Taking actions which maintain or enhance adaptive capacity (for example promoting diversity) may also provide 'no-regrets' adaptation options to minimise the future impacts of climatic and non-climatic changes on farming systems. Findings presented in this Chapter suggest that NGOs and government programmes focus on technical solutions aimed at increasing crop and/or livestock productivity in the short term. This also emerged from the policy analysis and policy stakeholder interviews presented in Chapter 7 and will therefore, be discussed further in Chapter 8.

Technical solutions identified in this Chapter often exclude consideration of the impacts this may have on diversity, resources and informal and formal institutions; though these are equally critical to maintaining and strengthening farming system adaptive capacity over time. These policies and programmes are in line with a global shift towards ‘modern agriculture’, which is highly standardised, large-scale, mechanised and reliant on relatively few uniform cultivars. In support of Stoop et al. (2002), this chapter also recommends a cautious approach to the promotion of modern agriculture because of the negative health, social and environmental impacts associated with high external-input use. Instead, identification and integration of appropriate modern farming methods should be pursued, further highlighting the need for a shift away from a one-size fits all approach and a consideration of the implications of this in the long term (Thompson, 2007).

The need for a broader perspective has significant policy relevance within and beyond Uganda. Firstly, it potentially challenges one of the broad strategies for increasing agricultural productivity in Uganda, which supports the dissemination and adoption of productivity-enhancing technologies. This assumption about the positive role for short-term technical solutions also underpins the current National Agricultural Policy (MAAIF, 2011) and underlies one of the pillars for achieving poverty eradication in Uganda. Examples of other short term, technical solutions and modernisation policies can be found across SSA (Horlings and Marsden, 2011, Jerneck and Olsson, 2013). However, evidence to support the positive relationships between such technical solutions and productivity, income generation and poverty reduction over time is inconclusive (Bahiigwa et al., 2005, Harris and Orr, 2014, Kassie et al., 2011).

Secondly, it highlights that there is a need to critically examine the goals of existing agricultural, development and adaptation policies and practices and identify the trade-offs and synergies. For example, the negative social and environmental externalities associated with agricultural modernisation have been well documented (Chamala, 1990), but are not necessarily considered by existing policies. This is important as it potentially undermines the capacity for future production (Fernandez et al., 2002). It further demonstrates that in order to enhance farming system adaptive capacity, targeted actions are needed for multiple actors across different sectors, including governmental and non-governmental actors (Harsh, 2014), and policies targeting different levels may be required (Cash et al., 2006). Chapter 7 provides additional insight into this and therefore represents an important step towards achieving this.

Thirdly, future empirical work into adaptation, vulnerability and resilience should not only consider the 'of something to something' (Carpenter et al., 2001), but also consider 'for who, where and when' (Leach, 2008), i.e., the distribution of costs and benefits across time and space. These findings confirm the importance of justice in adaptation research (Thomas and Twyman, 2005) .

5.6 Summary of Chapter 5

This chapter investigated the evolution of two farming systems in Uganda and analysed how adaptive capacity has changed over time. It has demonstrated that multiple pressures and opportunities have influenced the evolution of farming systems from 1960 to 2012. These trends have not only influenced adaptive capacity, but also characterise current farming systems and will therefore shape future adaptive capacity. In general, the shift to modern farming, including the range of interrelated sub-trends, such as shifts in farming methods, crop and varieties, represents a major change in both farming systems. Modernisation has had both positive and negative impacts on the components of adaptive capacity, where the most significant differences are related to diversity. Despite a range of changes, farming systems still remain important sources of food, income and livelihood. The major trends in the evolution of the JFS and SFS demonstrate that farming systems are dynamic and responsive to multiple pressures and opportunities operating at a range of spatial and temporal scales.

Using a mixed-methods and multi-level approach provided new, in-depth empirical data about two farming systems in eastern Uganda. Empirical evidence provided in this chapter also highlights the need to move beyond the narrow framing of farming systems as production systems. Furthermore, using a systems approach enabled the dynamic nature of farming systems to be explored at different levels. It enabled the identification of patterns across space and time. Patterns can be used to structure farm typologies or identify characteristics of smallholder farming (Tittonell et al., 2010, Dixon et al., 2001). Characterising farming systems in each study district, demonstrated the potential to link farming systems with geographical scales and administrative levels.

Policy support at the sub-national level should be tailored to the broader contextual conditions. For example, policy support in Jinja District needs to reflect the changing attitudes of the youth towards agriculture, and in Soroti District the important role of livestock as part of the SFS must be recognised and reflected in policies. This confirms that there is potential to link farming systems to recommendation domains (Collinson, 2000, Dixon, 2000).

Applying the FSAC framework demonstrated that 1) similar trends in farming system evolution have had differential impacts on the diversity of farming systems; (2) trends have contributed to the erosion of informal social and cultural institutions and an increasing dependence on formal institutions; and (3) trade-offs between components of adaptive capacity are made at the farm-level, thus influencing farming system adaptive capacity. To identify the actual impacts of future climate change and variability, it is important to recognize the dynamic nature of adaptive capacity. Such findings advance understanding about farming systems and adaptive capacity in the context of future climate change and variability.

Chapter 6 Household responses to past climate hazards: the role of adaptive capacity

Abstract

This chapter investigates household responses to past and present climate hazards (1960-2012) and explores the role of adaptive capacity therein. In doing so, it addresses Objective 2 of the thesis. Primary data from FGDs and semi-structured interviews are compared with secondary data. Primary data are then analysed within the FSAC framework (Figure 2.2) to draw insights from the findings from Jinja District and Soroti District. This investigation of household level responses uses the same time period as Chapter 5, which focussed on the farming system as a unit of analysis. Findings from both chapters contribute to an understanding of the dynamic nature of smallholder farming and adaptive capacity at different levels.

Findings suggest that a range of institutions operating across time and space interact to shape the ability of farmers to draw upon or substitute between resources at the farm level. Over time, households that are able to maintain flexibility and diversity at the farm level are better able to respond to climate hazards. This demonstrates a more complex relationship between exposure, sensitivity, adaptive capacity and impacts than is suggested by the framing of vulnerability in the climate change literature (Section 2.4). Research is needed to determine how other political, economic, social and institutional factors enable or constrain flexibility and diversity. Enhancing adaptive capacity requires greater consideration of farm-level diversity and flexibility in policy and practice that seeks to support adaptation to climate change and variability.

6.1 Introduction to Chapter 6

Historically, Uganda has been exposed to multiple climate hazards, including climate extremes, variability and changes. Yet, the geographical variations in the nature of these climate hazards are not well understood; and how farmers have responded to such hazards has not been well documented. Furthermore, there is growing concern about how climate change may impact upon Uganda and the extent to which it will exceed historical extremes and ranges of variability (RoU, 2007). Whilst there is a lack of scientific consensus on future rainfall trends (Osbahr et al., 2011) and research is ongoing, smallholder farmers across Uganda are responding to current climate hazards and changing climatic conditions.

The persistence of smallholder farming systems, despite exposure to multiple climate hazards, demonstrates adaptive capacity. Yet, how smallholder farmers mobilise latent adaptive capacity in response to exposure to climate hazards is underexplored (Section 1.4). To contribute to such debates, there is potential to examine how farm households have responded to past and current climate hazards (Objective 2). Although climate change may present new climate hazards, including climate extremes and variability, and require new technologies, knowledge and resources, the literature demonstrates that there is potential to gain useful insights from historical experiences (Osbahr et al., 2011, Vincent et al., 2013). Based on the notion that farmers have adapted to a range of climate hazards (Orlove, 2005), this chapter uses 'system inputs' components (resources and institutions) of the FSAC framework (Figure 2.2) to investigate Objective 2: how farmers have responded to past and current climate hazards (from 1960-2012). These findings could provide insight into how we can strengthen adaptive capacity and therefore enable adaptation to future exposure to climate hazards.

6.2 Research design, methods and analysis

Primary and secondary data are integrated to explore the relationship between exposure to climate hazards and adaptive capacity, which was identified as a gap in the literature reviewed in Chapter 2. Climate hazards were divided into: climate extremes; climate variability, and climate changes, which were defined as the perceived climate trends farmers have observed over the last twenty years (1990s-2012) compared with perceptions of a 'normal' climate (1960-1980s). This timeframe linked to how farmers distinguished between 'then' and 'now', which coincided with other political events (see Chapter 5).

Household responses to climate hazards were elicited and discussed alongside the relevant factors that enabled or constrained particular responses. System inputs, i.e. resources and institutions, emerged from the data as relevant components of adaptive capacity using the FSAC framework set out in Chapter 5. Institutions interact across scales, therefore demanding cross-scale considerations (Ostrom, 2010).

Semi-structured interviews and focus group discussions were used to identify the climate hazards farmers had experienced and to investigate how farmers have responded to climate hazards from 1960-2012. Secondary data from existing academic and grey literature were also used to triangulate primary data, specifically in relation to the types of climate hazards. Any discrepancies about dates were clarified during the verification FGDs (Section 4.3.7.6). Verification using multiple methods provides strong evidence for the type of hazards farmers have experienced. Using a combination of methods provided detailed accounts of the past, of how things have changed, particularly the relationships between climate hazards and other issues. Identifying climate hazards provides the necessary background for exploring farmers' responses and how they operationalised adaptive capacity.

Livelihood trajectories (Sallu et al., 2010) were used to analyse, organise and integrate primary and secondary data from the different methods for each District. Matrices were used to examine the relationships between climate hazards, adaptive capacity and farmer responses. The six livelihood adaptation classifications proposed by Agrawal (2008) and Vincent (2013) (outlined in Section 2.8.1) were integrated to provide a way of organising farmer responses. The Sustainable Livelihoods Framework (SLF) (see section 2.8.1) guided analysis of the resources that enabled farmer responses to climate hazards. Resources were categorised into human, financial, social, physical and natural categories.

How farmers access and utilise resources does not occur in an institutional vacuum (Agrawal and Perrin, 2010). Institutions, as defined in Chapter 2, were classified using Agrawal (2008)'s distinction between market/private, public/government or communal/civic institutions, also distinguishing between informal and formal institutions where appropriate. Some institutions could be placed in more than one category, for example, existing community power structures are both a civic and a public institution, and are therefore categorised as a 'combination' institution. Data analysis provided a summary of the relevant resources and institutions for each type of livelihood response.

6.3 Results

Results are split into three sections. Section 6.3.1 presents the past and present climate hazards (extremes, variability and changes) that farmers have experienced from 1960s to 2012. Section 6.3.2 draws insights from how farmers in the different study districts have responded to these hazards, whilst Section 6.3.3 explores how adaptive capacity has been operationalised to influence farmers' responses. Findings provide insight into the relationships between exposure to climate hazards and adaptive capacity, which are then explored in the discussion in Section 6.4.

6.3.1 Past and present climate hazards from 1960 to 2012

6.3.1.1 Climate extremes

In both study districts, farmers raised climate extremes as factors limiting agricultural production. They identified floods and droughts as the main climate extremes they had experienced, though they also highlighted recent storms and winds. Floods were linked to heavy rainfall and increasing groundwater levels. Droughts describe instances when water was not available in sufficient quantities for successful agricultural production.

Climate extremes described during FGDs and semi-structured interviews are presented in Table 6.1, where illustrative quotes are used to describe the event and secondary data is included to triangulate primary data. Farmers could describe particular extreme events, but in some cases, a range of dates was given for the same event (Table 6.1). Data also suggest that the cumulative effect of exposure to multiple climate extremes, especially in recent years, makes it difficult for people to isolate climate extremes from other environmental, political and socio-economic stresses. This highlights that farmers can have different recollections of the same event, depending on their memory and experience. However, there is largely convergence between primary data and secondary data, demonstrating that farmers' historical experiences can provide important insights into past climate extremes.

Findings suggest that between 1960 and 2012, farmers in Soroti District have been exposed to a higher frequency of and a wider range of climate extremes than those in Jinja District, both in terms of floods and droughts (Table 6.1). Until the 1980s, farmers across both districts noted similar climate extremes, for example, heavy rainfall and flooding in 1961/62. Differences in exposure to climate extremes emerge from the 1980s onwards. This is also consistent with the analysis of mean annual rainfall (1943-1999) presented in Uganda's 'State of Environment Report 2001/02' (NEMA, 2001).

Between 1980 and 2000, farmers in Soroti District remembered three droughts and one flood. In Jinja District two droughts and one flood were described. Heavy rainfall and flooding was experienced by farmers in both districts during 1996/97, however, droughts during 1980 and 2000 occurred at different times. The greatest disparity in exposure to climate extremes comes from 2000 onwards. Since 2000, farmers in Soroti District listed five climate extremes, including both floods and droughts. Farmers in Jinja District noted two droughts, which occurred between 2010 and 2012. Such disparity highlights that farmers have experienced different types of climate extremes since 2000.

Since 2000, farmers in both districts have experienced multiple climate extremes, more frequently than in the past (Table 6.1). Data also highlight an increase in the frequency of droughts in Jinja District. Following such droughts farmers in Jinja described experiencing other climate extremes, such as periods of heavy rainfall, strong winds and storms. Findings from Soroti District are similar, yet farmers emphasised more instances of heavy rainfall and flooding since 2000, in addition to periods of drought.

Table 6.1 Illustrative quotes from semi-structured interviews and focus group discussions describing past climate extremes experienced by farmers in Jinja District and Soroti District. The tables includes primary data to describe the extremes and where available, secondary data is included to triangulate primary data.

Climate Extremes	Year	Description of Event	Secondary data	Source
		Jinja District		
Heavy rain and floods	1961/63	*"in 1961 there was a lot of rain"* *"we got independence in 1962 and the same year again we got floods"*	Mean Annual Rainfall 1961-63: "Very Wet" La Niña	(NEMA, 2001) (Conway et al., 2005)
Drought	1979 - 1982	*"drought, too much sunshine, cows died, people lost their cattle"*	Mean Annual Rainfall 1979-80: "Dry"	(NEMA, 2001)
Drought	1988 - 1991	*"sunshine and drought, no rain"* *"that year we only planted one season and it was not enough"*	Mean Annual Rainfall 1988: "Very Wet" 1989: "Dry"	(NEMA, 2001)
Heavy rain and floods	1996/97	*"heavy rainfall throughout the year"* *"it was bad for crops ….and we had diseases like cholera"*	Very high rainfall Mean Annual Rainfall 1998: "Very Wet" La Niña	(NEMA, 2005) (NEMA, 2001) (Conway et al., 2005)
Drought, heavy rains and storms	2010/11	*"there was too much sunshine"* *"in the second season of last year, the rains were too much. The harvest was bad."*	No data available	No data available
Drought, heavy rain, and storms	2012	*"like last year [2011] they used to call it [famine] 'olukoba' (local language for rubber band)…. This year they are calling it 'warid' (name of a mobile phone network)"*	No data available	No data available

Climate Extremes	Year	Description of Event	Secondary data	Source
Soroti District				
Heavy rain and floods	1961 / 1962	*"there was a great flood"*	Mean Annual Rainfall 1961-63: "Very Wet" La Niña	(NEMA, 2001) (Conway et al., 2005)
Drought	1979/80	*"a drought came in which made people not to farm and the fighting was there which also stopped people"*	Mean Annual Rainfall 1979-80: "Dry"	(NEMA, 2001)
Drought	1984	*"In 1984 people did not farm because there as a severe drought. People started farming in 1985, when the rains started coming. But then again in 1985 some trouble came and it brought even more poverty"*	Mean Annual Rainfall *1983-85: "Normal"*	(NEMA, 2001)
Drought	1993/94	*"In 1994 there was a serious famine as a result of that dry spell. People were resorting to eating wild foods, like some tree species that were not known as being edible, people had to go to them and take them for food"*	Drought Mean Annual Rainfall: "Normal"	(NEMA, 2005) (NEMA, 2001)
Drought	1996/7	*"in this year 1996 it was very bad...it was serious, there was total drought"* *"the bad weather, it was in 1997, anyway there was a lot of famine in that year"*	Very high rainfall La Niña	(NEMA, 2005) (Conway et al., 2005)
Heavy rain and floods	2003/4	*"wherever Kony would stop there was rain, so there was a lot of rain during 2003"*	No data available	No data available
Heavy rain and flooding	2006/07	*"there was a flood, a very dangerous flood that destroyed houses and crops"* *"it started in August and went September, October , November and December; people were having Christmas when those floods were still there"*	Very Wet	(NEMA, 2001)

Climate Extremes	Year	Description of Event	Secondary data	Source
Drought, heavy rain and floods	2009/10	*"In 2009 there was drought, so the 2009 dry season extended. We then experienced famine in 2010. Then in 2010 we had floods from extended rainfall in the second season (June – September)"*	No data available	No data available
Heavy rain and floods	2011	*"in 2011 there was some good times though some people suffered from a flood"*	No data available	No data available
Drought, heavy rain and floods	2012	*"Even this very year there is a drought. Previously by this time people would have finished the first weeding on their maize, it would be 1 metre above the ground, but there is no rain"*	No data available	No data available

During FGDs in both districts, drought was cited as occurring more often than flooding and ranked higher as a priority issue affecting agricultural production. However, the distribution of droughts between 1960 and 2012 differs between the study districts. Apart from recent years (2010-2012), farmers in Jinja District described droughts as something which occurred in the past, highlighting that droughts were not considered as a 'normal' climate feature. During semi-structured interviews, farmers in Jinja District explained:

> *"Long ago there were droughts that we would hear of, that our grandparents would tell us of …. soya bean was imported from outside and brought to Uganda and they used it to give to households, then they go and make a line from sub-counties, sub-county Headquarters and every homestead was given some."*

(Male Respondent, Bukolokoti, Jinja District, 2012).

> *"Now every year it is coming that we have a drought, every year it comes."*

(Male Respondent, Bituli, Jinja District, 2012).

Data from Soroti demonstrate at least one drought occurring every decade since the 1980s, for example 1984, 1993/94 and 2009 (Table 6.1), suggesting that such extremes are a feature of the Soroti climate.

> *"Even before [2007], droughts and floods had happened, but I am not able to recall the years."*

(Male Respondent, Adamasiko, Soroti District, 2012).

Farmers also expect droughts at particular times of the year, meaning that not all droughts are a problem, rather, the timing and duration are important:

> *"The problem….the droughts came in times we did not expect them. It limited growth of some crops and there was no proper harvest"*

(Male Respondent, Kangeta, Soroti District, 2012).

Farmers across both districts raised concerns about heavy rainfall due to their experience of this in recent years. Periods of heavy rainfall have caused groundwater levels to rise, resulting in waterlogging and localised flooding. Such floods featured more prominently in

Soroti District, perhaps due to its geographical location in the Lake Kyoga plains, where more people live and farm in low lying areas.

Within each study district farmers also had different experiences of heavy rains and flooding due to variations in geographical locations and topography of the villages. Those living in or next to low lying areas, for example swamps, were exposed to flooding. Additionally, farmers stated that increases in flooding are not only caused by heavy rainfall, but also by changes in agricultural practices, for example, increased cultivation in wetland areas, which has increased the sensitivity of the farming system. Despite different experiences of flooding, it was described in both districts as a high impact event, even though it may not affect everyone in the area (Table 6.2).

Data demonstrate that farmers in each district also had different experiences of drought and used the word drought in different ways. For example, in Soroti District, farmers used the word drought to refer to the dry spell at the beginning of a season as well as any prolonged or unexpected dry spell, whereas farmers in Jinja District used drought to refer to unexpected or prolonged dry spells. Results show that farmers have not only experienced different types of drought, but also use the word to describe the impacts rather than the event (cf. Osbahr et al., 2010, Simelton et al., 2013). For example, in Jinja District drought was used to describe a food shortage or famine, even if it was not related to a lack of water. These findings highlight how past experience of climate hazards shape how people use the word drought.

Table 6.2 Comparison between experiences of flooding in Jinja District and Soroti District

	Illustrative quotes from Jinja District	**Illustrative quotes from Soroti District**
Impacts of flooding	*"When flood comes, it does not spare anything. But droughts, they may find when I have some food in the house. In my house we can't talk about floods, that is very dangerous."* (Male Respondent, Idoome, Jinja District, 2012). *"Here, we just get simple floods in the swamps, like the area you have passed, it floods for a few hours or a few days"* (Male Respondent, Bukolokoti, Jinja District, 2012).	*"Once there is heavy rainfall, then we experience flooding and once the flooding comes it really attacks the people who are near the swamps and wetlands. It attacks the gardens, the cassava, and any other crop that is planted there just has to rot in the garden".* (Male Participant, Kangeta, Soroti District, 2012). *"That rain that brings floods, when it becomes too much, it can cover the whole place and flood the whole gardens..it becomes too much for the crops".* (Male Respondent, Agirigiroi, Soroti District, 2012)
Occurrence of flooding	*"We don't get floods, we just hear about them, like in Mbale [District]. They are affected by floods"* (Male Respondent, Bukolokoti, Jinja District, 2012).	*"The problem we have here is flooding. When there is too much rain the water really comes and covers the whole farm, it is flooding."* (Female Participant, Merok, Soroti District, 2012).
Geographical variation	*"Generally we are on a highland, but yes in simple swamps they do flood"* (Male Respondent, Bituli, Jinja District, 2012).	*"For me here, it is not common around my home, but when you move around the floods are dominant down there and even the neighbouring places to Agirigiroi they also experience the floods."* (Male Respondent, Agirigiroi, Soroti District, 2012).
Drivers of flooding	*"Some of these swamps have been disorganised by rice growing so at times they block their natural drainage … and it will flood. But that is because of that."* (Male Respondent, Bituli, Jinja District, 2012).	*"I have seen in the wetlands people have encroached there. They have caused lots of siltation there, so when it rains they flood very fast and the water floods to the highland areas."* (Female Respondent, Agirigiroi, Soroti District, 2012).

6.3.1.2 Past climate variability

As climate variability is set to increase under future climate change scenarios in Uganda (Christensen et al., 2007), this section seeks to understand what types of variability farmers have experienced. Understanding past variability and how farmers have responded may provide additional insight into understanding how farmers may respond to future variability.

Results for Jinja District are split into two time periods, 1960-2009 and 2009-2012, to match the time at which farmers in Jinja District started experiencing variability. Although in Soroti District farmers describe an increase in variability in recent years, data also suggest that these farmers have historical experience of climate variability, therefore data were organised to cover the whole time period from 1960-2012. Identifying past climate variability requires an understanding of a 'normal climate', data on which was obtained from farmers using rainfall calendars during FGDs (Table 6.3).

Farmers in both Districts distinguished between the types of weather they could expect in a normal climate by referring to particular months:

> *"For us we depend on that experience to know when we should begin expecting in this particular period we should receive the rains"*

(Male Respondent, Bukolokoti, Jinja District, 2012).

> *"People used to rely a lot on the month and the experiences they had. They knew that every year around March 15th rains have to come back, so they start preparing their gardens before March. That was just based on experience and knowing that in March rains will be there."*

(Male Respondent, Adamasiko, Soroti District, 2012).

Table 6.3 Perceptions of 'normal' climate from interviews and FGDs with farmers compared with examples of past inter-annual and seasonal rainfall variability from secondary data, during the period 1960 to 2012.

	Jinja District	Secondary data	Soroti District	Secondary data
'Normal' Climate	Bimodal rains (March-May and September – November/) Lower rainfall and hotter periods in January / February	Bimodal: March – May, September – December. Low rainfall: December-March and June-July (JDLG, 2011, NEMA, 2009)	Bimodal rains (March-May and July –November) Distinct dry, hot spells in June and from November – February	Bimodal (March–June, August – November). Dry Spells: November to March (NEMA, 2009, SDLG, 2011)
Inter-annual variability	Historically (1960-2009) little inter-annual variability described. Since 2009 variability in: • Onset of first rains • Amount and intensity of rainfall • Distribution of rainfall across the year	Annual rainfall: 1250 – 2000mm (NEMA, 2009) Interannual variability linked to El Niño Southern Oscillation (Phillips and McIntyre, 2000)	Historically (1960-2012) some experience of inter-annual variability in terms of: • Onset of first rains • Amount and intensity of rainfall • Distribution of rainfall across the year	Annual rainfall: 1,200mm – 1,450mm (NEMA, 2009) Interannual variability linked to El Niño Southern Oscillation (Phillips and McIntyre, 2000)
Seasonal variability	Historically (1960-2009) little variability described. Since 2009 variability in: • Amount and intensity of rainfall in each season	First rains becoming less reliable more variable (Oxfam, 2008) Increased risk of mid-season drought (Osbahr et al., 2011)	Some experience of variability from 1960-2012: • Amount and intensity of rainfall in each season	First rains becoming less reliable more variable (Oxfam, 2008) Increased risk of mid-season drought (Osbahr et al., 2011)

Farmers in Jinja District described a stable, predictable ‘normal’ climate, with two growing seasons (February/March-June and September-November) and drier, hotter periods in December and January (Figure 6.1). Farmers in Soroti District also described two growing seasons linked to rainfall patterns (February/March-May and July–November), with a distinct dry spell in June and another lasting from around November to February (Figure 6.1). Farmers’ agricultural practices can influence their perceptions of a normal climate. Practices vary between households, depending on their access to land and other household resources, for example labour, financial resources and the crops that they grow, as different crops require different growing conditions. This can result in variation between cropping calendars within the same geographical area. However, normal climates and inter-annual variability described by farmers concur with secondary data.

Table 6.3 shows that farmers in Jinja District and farmers in Soroti District have had different experiences of past inter- and seasonal variability, highlighting different levels of exposure to climate variability. Apart from 2009 onwards, farmers in Jinja District articulated experiencing very little inter-annual rainfall variability. This can be contrasted with views of farmers in Soroti District, who described experiencing historical variability between the timing and amount of rainfall they receive:

> *“Some years enough rain comes and other there’s little rain. It’s like that all years through. Sometimes you have enough rain, other years you have too much rains and some very little for agriculture…. Some rains come in March, then other years they come back in April, just like this year.”*

(Male Respondent, Adamasiko, Soroti District, 2012).

In addition, Soroti farmers noted greater seasonal variability, with differences between the rains in the first and second season. In Soroti District, normal rains in the first season are perceived to be heavier, whilst second season rains were perceived to be lighter. Consequently, farmers plant different crops, and in some cases different varieties of the same crop, in each season. Overall, farmers in Jinja District did not consistently describe differences between the rains in the first and second seasons and planted the same crops and varieties in the first and second season.

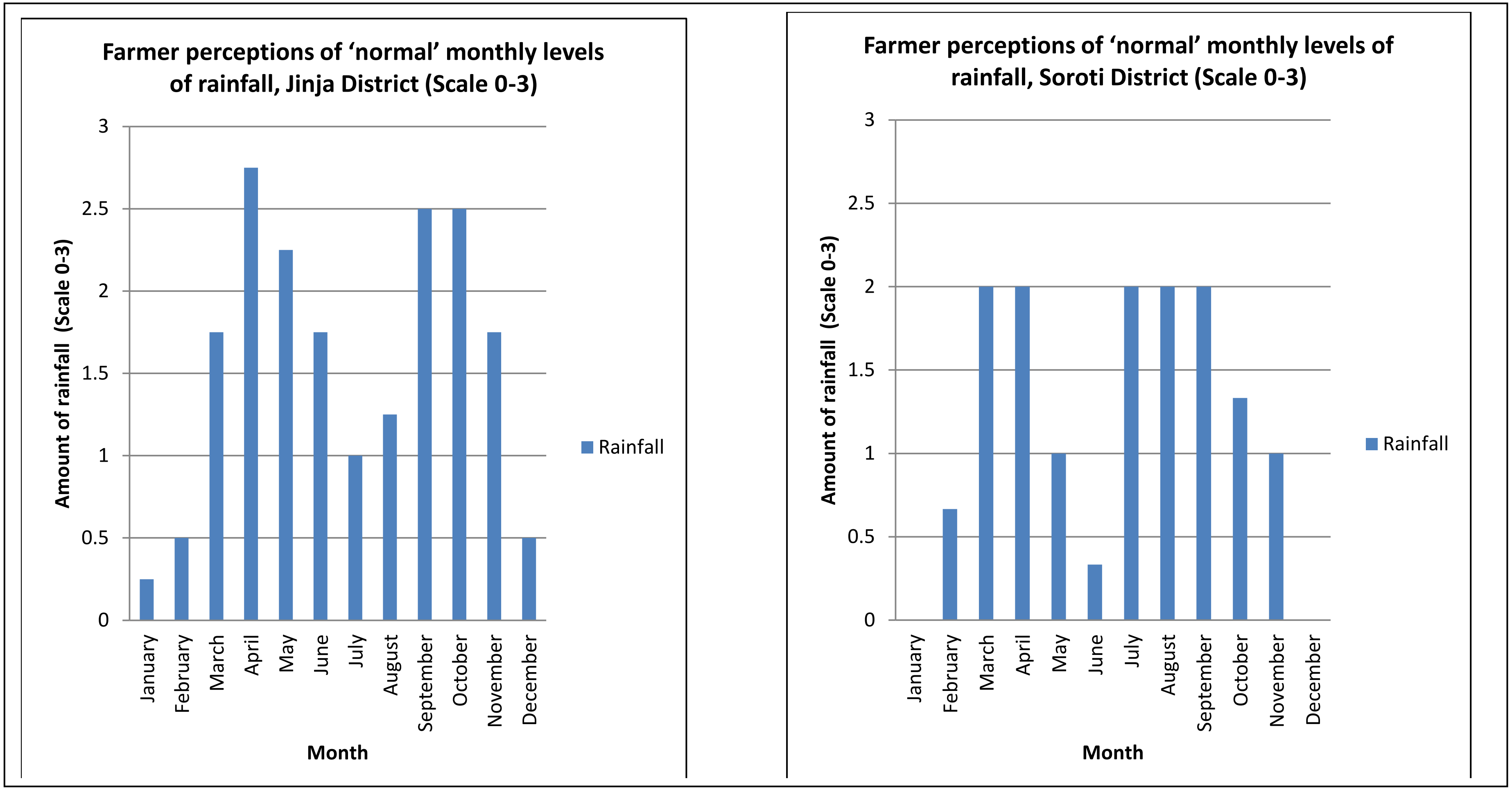


Figure 6.1 Farmer perceptions of a normal climate, data from rainfall calendars across the study villages (Jinja District, n=4; Soroti District n=3)

6.3.1.3 Perceived climate changes: comparison of 1960-1980s and 1990-2012

As there is a strong link between perception of climate risk and behaviour (Grothmann and Patt, 2005), understanding perceived climate changes is important. Given that these observations will be based on current or recent experiences, they will provide insights into how farmers may respond in the near future, for example between now and 2030. Current experiences provide an important link between farmers' past experiences and the potential for future adaptation.

Overall, primary data from Jinja District show temperatures are increasing, especially in the dry season. In Soroti District, an increase in temperatures only emerged in two out of four of villages in Soroti District. In Jinja District this emerged from all four villages.

Data from both study districts highlight that rainfall patterns are changing. Farmers made similar observations about changes in the characteristics of rainfall, in particular in relation to the amount, intensity and frequency:

> *"There are some changes in rainfall patterns. When I was growing up rains could go up to September and rains decrease in intensity, so at the end of November there was no rains. So there was a dry season. Then in early or late February some drizzles occur. So by March rains would have returned. But these days …. it has changed these days. It doesn't rain like it used to in those days"*

(Female Respondent, Kangeta, Soroti District, 2012)

The amount and distribution of rainfall within the season are also changing, meaning that farmers are not receiving the amount of rain that they expect at particular times. Changes in the timing of rainfall highlight a general perception that rains in the first season come 'later than before'. Data did not suggest changes in the cessation of the first rains, resulting in a shorter rainfall and growing season (cf. Osbahr et al., 2011).

Table 6.4 Illustrative quotes to highlight changes in climate observed across the study districts, (compared with perceptions of a normal climate).

Observations	What has changed?	Description of Change	Qualitative Evidence from Jinja District	Qualitative Evidence from Soroti District
Changes in timing of rainfall	Onset	Delayed onset of first rains	*"These days God has changed things again, these days now we get rain from March/April, that's how we are seeing it. That's how it is."* (Male Respondent, Bukolokoti, Jinja District, 2012)	*"These days the rains don't come early."* (Male Respondent, Adamasiko, Soroti District, 2012): *"But these days, like this very year, the rains come very late, people should be weeding but you find them just beginning to plant."* (Female Respondent, Kangeta, Soroti District, 2012)
	Duration	No change in cessation, resulting in shorter duration first season	NO OBSERVATIONS REPORTED	NO OBSERVATIONS REPORTED
Changes in characteristics of rainfall	Amount	Increase in the amount of rainfall	*"[We get] too much rain, it again spoils the crops, it's like that".* (Male Participant, Idoome, Jinja District, 2012)	*"The pattern is almost still the same, but there are slight changes maybe on the amount of rainfall."* (Male Respondent, Adamasiko, Soroti District, 2012)

Observations	What has changed?	Description of Change	Qualitative Evidence from Jinja District	Qualitative Evidence from Soroti District
	Intensity	Increase in the intensity of rainfall	"Why is it these days that we receive no rains or heavy rains, can you enlighten me" (Female Participant, Kalugu, Jinja District, 2012) "It takes long to come, then when it comes, it is heavy and comes with storms and it spoils crops." (Female Participant, Bukolokoti, Jinja District, 2012)	"These days it can come when it is too much in a very short time" (Male Respondent, Adamasiko, Soroti District, 2012) *"When the first rains come back they are becoming heavy and destructive"* (Female Respondent, Adamasiko, Soroti District, 2012)
	Frequency	Change in the distribution of rainfall	*"From august to December up to February, those were months of rain. But these days now it has not rained for 2 weeks and the crops have dried up. It has taken long"* (Male Respondent, Kalugu, Jinja District, 2012) *"We now experience little rains and it comes periodically. Not like those past days, we could get rain."* (Male Respondent, Bituli, Jinja District, 2012)	*"The rains are unreliable and droughts are occurring"* (Female Respondent, Adamasiko, Soroti District, 2012)
Changes in temperatures (Sunshine)		Increases in temperatures	*"those days there was not much sunshine but these days, it's too much"* (Female Respondent, Bituli, Jinja District, 2012)	*"temperatures have risen… at certain times especially in the dry season"* (Male Respondent, Agirigiroi, Soroti District, 2012)

In both districts, similar changes in the intensity of the rainfall were described. Findings suggest that intense rainfall is increasingly accompanied with strong winds, thunder and lightning (Table 6.5). This links to other changes farmers described associated with the increase in frequency and intensity of extreme events, i.e. the physical impacts of changes in climate. In Jinja District, farmers have observed increases in the frequency of droughts and storms, but although data show heavier rainfall, farmers did not report increases in flooding. This can be contrasted with data from Soroti District, where farmers narrated an increase in the frequency and intensity of droughts, floods and storms.

According to the data presented in this section, both inter-annual and seasonal variability are increasing (Table 6.5). This variability is characterised by prolonged and unexpected dry spells, unpredictable rainfall patterns and in some cases shorter growing seasons. Data also suggest spatial variability in rainfall distribution, where current rainfall covers part of the village or a neighbouring village and not the other, whereas in the past the rainfall would cover the whole area. An increase in spatial variability of rainfall was raised in some villages in both districts, but no consensus emerged. This may be linked with what farmers were experiencing at the time of data collection, rather than a change observed over a number of years.

Table 6.5 Illustrative quotes from semi-structured interviews and focus group discussions to highlight observed changes in climate extremes and variability, (compared with perceptions of a normal climate)

Observations	Description of Change	Qualitative Evidence from Jinja District	Qualitative Evidence from Soroti District
Increase in climate extremes	Drought: Increase in the frequency, intensity and unpredictability of droughts	*"We are getting periods of no rain and extended sunshine, so the crops dry in the gardens."* (Male Respondent, Bukolokoti, Jinja District, 2012) *"Sometimes [drought] can come, like this season, and attack you and even enter into the second season."* (Female Respondent, Kalugu, Jinja District, 2012)	*"It [drought] was shorter, it was November up to January. From February we could get some heavy rains."* (Male Respondent, Agirigiroi, Soroti District, 2012)
	Floods: Increase in the frequency and intensity of localised flooding	NO OBSERVATIONS REPORTED	*"there was less floods in that time, it was not dominant like now, it is very common these days."* (Male Respondent, Agirigiroi, Soroti District, 2012) *"when the heavy rains occur, it is actually the heavy rains that cause floods. When the heavy rains don't occur, then the floods don't occur."* (Female Participant, Adamasiko, Soroti District, 2012)
	Storms: Increase in the frequency and intensity of storms	*"these days the wind comes too much....it comes too much, it comes and blows too much."* (Male Respondent, Bukolokoti, Jinja District, 2012) *"these days we get rainfall with a lot of strong winds and storms. It comes with thunder."* (Male Respondent, Kalugu, Jinja District, 2012)	*"It is also accompanied with a lot of winds, not a gentle rain that falls. Now it's so much stormy."* (Male Respondent, Adamasiko, Soroti District, 2012):

Increase in climate variability	Seasonal: Change in the seasonal distribution of rainfall - more rainfall in the second season	*"Whenever it [rainfall] comes, people plant, no particular month, so there is no proper season....it is all about when it rains."* (Male Respondent, Bituli, Jinja District, 2012) *"Those days the rains of first season were much, but these days the rain of second season that comes in August comes much."* (Male Respondent, Bukolokoti, Jinja District, 2012)	*"We are getting heavier rains in the second season, as the second season approaches the heavy rains now come."* (Female Respondent, Agirigiroi, Soroti District, 2012) *"the second season is almost the best. It can start in July and rains can never stop and rain until December. It's raining all throughout."* (Male Respondent, Adamasiko, Soroti District, 2012)
	Inter-annual: Increase in the unpredictability of rainfall – timing, amount and distribution	*"These days there is no particular timing; it all depends on the season."* (Female Respondent, Kalugu, Jinja District, 2012) *"If we try to predict rain and changes in rain you will not find it there, you cannot know today is going to be like this."* (Male Respondent, Idoome, Jinja District, 2012)	*"It is very difficult to predict which year is the normal rain going to come and at what time of the year."* (Male Respondent, Merok, Soroti District, 2012)
	Spatial: Increase in spatial variability	*"the rain can be there in the other place, but not here, like this year, rains have delayed to come here."* (Male Respondent, Kalugu, Jinja District, 2012)	*"These days the rain is selective in the way it rains and falls, because you can see it coming, but it goes to another place and falls in another area or village and even there it rains in patches. But in those days the rain would come and fall in the whole area."* (Male Respondent, Adamasiko, Soroti District, 2012)

The study Districts have had difference experiences of flooding. Due to changes in the timing, amount, and distribution of rainfall, data highlight that farmers perceive that rainfall is becoming more unpredictable. This suggests an increase in seasonal and inter-annual variability, and potentially increased spatial variability. Some of these perceived changes, along with experiences of other climate hazards, are outlined in the examples provided by Case Study 4 (Box 4) and Case Study 5 (Box 5).

Box 4 Case Study 4 : Geoffrey & Mary, Farmers, Bukoloti Village, Jinja District

Geoffrey describes a number of climate related challenges that he is facing. He describes past weather patterns as being very predictable for farmers and would provide enough rains for two growing seasons. In the past he has used the months to guide him as how the rains will be. However, over the last 5 years, he has observed that increasing droughts and storms are causing problems for people in the village and that this method of relying on the months is no longer reliable. He also thinks that rains in the first season are coming later and it is difficult to predict how the seasons will be; this is causing him to shift his farming practices. For example, Geoffrey started planting trees to provide shade for coffee and cocoa, which can then also be harvested for timber in the future. He adapts the amount and number of times he sprays his crops with chemical pesticides, according to how he sees the weather conditions.

Mary, Geoffrey's first wife, is responsible for feeding her children and grandchildren who are living at home, where they mainly eat maize and beans. Mary recalls some difficult years in the 1980s when prolonged dry spells and little rainfall made is difficult to provide for her family. She describes how they had granaries of food, but once these were depleted she went into the forest looking for food and insects. These forests have since been cut down and the household no longer has a granary due to low productivity and concerns about theft. Government pine tree plantations, households, and sugarcane plantations now occupy the space where the forests once stood.

In 2011, heavy rains, accompanied with strong winds, caused floods and damaged a lot of crops in the village. Geoffrey and Mary lost some of their crops. The only other flood Geoffrey can remember was in 1962 when Uganda gained independence, but he fears that they are increasing. For Geoffrey floods didn't used to be a problem, but since he planted vegetable crops in lowlands and lost them in 2011, he now fears heavy rainfall. To cope with the food shortages in 2011, Mary bought dried food from nearby trading centres. She was able to buy this food using cash generated from other livelihood activities.

Box 5 Case Study 5.: Patrick, Male Farmer, Agirigiroi Village, Soroti District

Patrick, 48, has lived in Agirigiroi all of his life, apart from when there was instability in the area around 1986. He lives in a grass-thatched house with his family of 12. Through stories his father told him, he has ways of predicting the onset of the rainy season, *"first of all the winds, secondly the trees, when they begin putting back the leaves, and then the clouds also begin forming in the sky and also the temperatures increase …. they are the signs that the rains are about to come. Even the frogs and toads begin croaking and also some bird species begin singing. Then you get to know the rains are about to come".*

He has observed recent changes in rainfall patterns and is finding it increasingly difficult to rely on his local knowledge to predict the rains. 'Normal rains' have changed to include increased dry spells during a rainy season, shorter rainy seasons and heavier rainfall in the second season, *"they [rains] can come with great strength and destroy the house and even destroy the crops. Other times it can come very well and normally, with no thunder and lightning. People say that is a normal one, that is a good rain"*.

Patrick remembers some difficult years in the village due to climate extremes such as floods and droughts. He says that people had ways of coping, for example they would store a lot of food and eat from their granaries. In the case of prolonged droughts such as those in 1980s his family would eat leaves, bark from trees and insects, or walk to neighbouring villages to find food. He also recalls 'serious' floods in 2008 flood, where he remembers local leaders made a list of those badly affected for the government and other NGOs, who then distributed some food, clothes and shelter to those living and cultivating in the low lying areas. The floods didn't directly affect Patrick, as his land is on higher ground. However during this time, some people would work on his land in exchange for food or seeds.

6.3.2 Farmer responses to climate hazards

Findings presented in the previous section highlight past and current climate hazards farmers have experienced. The aim of this section is not to quantify the effects of these responses on farming system productivity or make judgements about responses. Instead, the purpose is to explore how farmers have responded to climate hazards, to then further unpack how adaptive capacity shapes farmer responses. Such findings can advance understanding of the relationship between exposure and adaptive capacity.

Responses were listed according to the type of hazard (extremes, variability or change) to which they related (Table 6.6). Responses were organised into different categories to include the range of livelihood adaptations available to farmers, including both reactive and proactive responses. Where a particular response was linked to a specific type of extreme, variability or change, this has been noted. For example, responses with an ‘F’ after them highlight responses to flooding. If no letter follows the response then it was described as a general response in that category (Table 6.6). A footnote system is used in Table 6.6 to highlight where there was disagreement between villages and households within the study Districts and also to explain any caveats to farmer responses. As farmers associate changes in temperature with changes in rainfall, this section focuses on farmer responses to changes in rainfall only.

Table 6.6 Farmer responses to past climate hazards (extremes, variability and change). Key *Floods only – F; Droughts only – D; Seasonal Variability only –SV; Inter-annual Variability only- IA. Onset only O.*

Onset only -O

Strategy	**Jinja District**			**Soroti District**		
	Extremes	**Variability**	**Change**	**Extremes**	**Variability**	**Change**
Storage	Store food* (D) Reduce food intake (D) Reduce expenses by consuming less (D)	Store food and seeds* Accumulate productive resources, e.g. goats	Store food and seeds* Accumulate productive resources	Save and store food Reduce food intake Reduce expenses by consuming less	Save and store food and seeds Accumulate productive resources, e.g. livestock	Save and store food and seeds Accumulate productive resources

Strategy	Jinja District			Soroti District		
	Extremes	Variability	Change	Extremes	Variability	Change
Livelihood diversification	Seek casual work opportunities (D) Draw on natural resources (D)	Seek casual work opportunities Seek other natural resource based activities Cultivate cash crops (e.g. sugarcane, fruits, vegetables) ** Joining groups, e.g. women's groups +	Start new businesses Seek other natural resource based activities Cultivate cash crops (e.g. sugarcane, fruits, vegetables) ** Seek opportunities – urban areas Land use change – mono-cropping e.g. sugarcane *** Joining groups, e.g. women's groups +	Seek casual work opportunities Draw on natural resources	Seek casual work opportunities Seek other natural resource based activities Start new businesses Joining village saving schemes +	Start new businesses Cultivate cash crops (e.g. beans, fruits, vegetables) ++ Seek other natural resource based activities Seek opportunities – urban areas + Joining village saving schemes + Crop diversification ++

Strategy	Jinja District			Soroti District		
	Extremes	**Variability**	**Change**	**Extremes**	**Variability**	**Change**
Communal pooling	Draw on neighbours and social support networks (D) Receive external government support (D)	Draw on neighbours and social support networks	Draw on neighbours and social support networks	Draw on neighbours and social support networks Request/receive external government/NGO support	Draw on neighbours and social support networks	Draw on neighbours and social support networks
Market Exchanges	Sell resources (D) Buy food (D)	Sell resources *** Buy food Rent out resources **	Sell resources *** Buy food Rent out resources **	Sell resources Buy food	Sell resources	Sell resources
Mobility	Temporary migration of some members of the household to look for food / money (D)	Urban migration **	Urban migration ** Rural migration – places with more land **	Temporary migration of some members of the household to look for food / money	Urban migration+	None recorded

Strategy	Jinja District			Soroti District		
	Extremes	Variability	Change	Extremes	Variability	Change
Modification	Change planting date (D) Plant drought tolerant and fast maturing varieties (D) Early harvesting (D)	Change planting dates (IA) Plant 'food security crops' (e.g. fast maturing sweet potatoes) +* Cultivate new crops and varieties (sugarcane, vegetables) (IA) ***	Change planting dates (O) Plant 'food security crops' (e.g. fast maturing sweet potatoes) +* Early harvesting (SV, F, D) Cultivate new crops and varieties (sugarcane, vegetables) ** Intensification practices***	Change planting date (D) Plant drought tolerant crops, e.g. cassava (D) Fast maturing varieties Early harvesting Change planting location - plant in swamps (D) or highlands (F)	Change planting dates (IA) Plant 'food security crops' (e.g. fast maturing or drought tolerant varieties) +* Early harvesting (SV) Cultivate new crops and varieties (IA) Dig local dams to store water Plant crops in specific seasons (SV)	Change planting dates (O) Plant 'food security crops' (e.g. fast maturing or drought tolerant varieties) +* Early harvesting (SV, F, D) Cultivate new crops and varieties ++ Dig local dams to store water Plant crops in specific seasons (SV) Vary planting dates (SV) Intercropping ++ (SV)

Footnotes Table 6.6.

* No consensus on this. This practice is in decline as evidenced by the lack of granaries, but that some farmers respond in this way

** Data highlight multiple drivers of this trend, including links with land fragmentation, declining soil fertility, declining interest in agriculture.

*** Data highlight multiple drivers of this trend. Across Jinja District this is predominantly market driven by the private sector, e.g. sugar companies.

+ Differences between households and villages.

++ Differences between households. Data highlight multiple drivers of this trend –in Soroti it links to climate suitable for new crops, new crop varieties being available, and extension services to deliver training and inputs. Some households are able to take advantage of changes in weather, depends on access to seeds, knowledge etc.

+*Differences between planting food crops to sell, planting for home consumption, or a combination thereof. Sometimes selling food crops is to take advantage of market opportunities, e.g. maize in Jinja District and cassava in Soroti District.

6.3.2.1 Responding to climate extremes

Farmers draw upon a range of strategies, from across the different categories, highlighting that multiple strategies are available to farmers. Responses to climate extremes in Jinja are mainly associated with drought; this is due to lack of consistency in data about flooding. Data presented in Table 6.6 show that similar strategies are used across the study districts to respond to climate extremes. This demonstrates that farmers can respond in similar ways, despite being exposed to different types of climate extremes.

Farmers use livelihood diversification strategies and market exchanges, regardless of the nature of the extreme. In addition to this, they also reduce their food intake and draw upon the support of friends, family and neighbours. During FGDs and semi-structured interviews these were identified as general responses used to cope with a range of climatic and non-climatic pressures. As one farmer explained:

> *"People always try to look for ways of saving something in case of even weather variations or other things, people at least have something they have saved in their granaries."*

(Male Respondent, Adamasiko, Soroti District, 2012).

Farmers in both districts adjust their management practices in response to climate extremes. However, the specific strategies they implement vary both between and within districts. In both districts, farmers reported adjusting planting dates, the crops and varieties under cultivation, and early harvesting in response to climate extremes. However, data from Soroti District also show that farmers change the planting location, depending on the nature of the extreme. For example, some people plant in low-lying area or swamps in response to drought, whereas they plant in highlands following a flood. These strategies were not listed by farmers in Jinja District.

Other notable differences are in the nature of storage and communal pooling in response to climate extremes. In Soroti, farmers described saving and storing food in response to past and current climate extremes. Although some farmers described the importance of this in Jinja District, the practice of storing the food they had produced was not widespread. Instead, farmers noted that they would sell their harvests to generate money for other household needs and then buy foodstuffs such as dried sweet potatoes to store. In addition, Soroti farmers have both requested and received help from external agencies, for example, government and NGOs provided support (food, clothing and blankets) following floods in 2007. Farmers in Jinja could not recall any recent (last 5 years) support from either government or NGOs following exposure to climate extremes.

6.3.2.2 Responding to climate variability

In response to climate variability, farmers use similar storage, livelihood diversification and communal pooling responses across the study districts, for example, seeking casual work, drawing on natural resources and eliciting support from social networks. However, there are differences between how management modifications, market exchanges and mobility are used. In Soroti District, data show that farmers cultivate certain ‘food security’ crops and store food to prepare for climate variability. This reduces the food they have to buy, thus limiting responses classified as market exchanges. Data from Jinja District show that some farmers will plant certain ‘food security’ crops, but that buying food and then saving it is more common. The widespread nature of this in Jinja District means that households have resorted to selling resources and buying food, and thus rely more heavily on market exchanges.

In both study Districts, responses to climate variability include both reactive and active strategies. Active actions include asset accumulation, for example, of livestock, to provide a safety net. Farmers are also diversifying, for example, by starting new businesses and seeking alternative income generating activities. Whilst farmers may not be receiving any support from external organisations, some are joining groups or village saving schemes to prepare for and deal with climate variability.

Farmers also use a range of reactive strategies to minimise the impacts of climate variability, for example, reducing food intake, selling resources, adjusting agricultural management practices such as crop planting dates. Additionally, in Jinja District, mobility is used as a response to climate variability and other pressures. Some members of the household are migrating to rural areas with more available land or to urban areas to diversify their income sources. Although there are some individual examples of this in Soroti, this was not a consistent finding across villages and households. Furthermore, data show that farmers in Soroti District have historically used mobility as a response to other non-climatic stresses and are now returning from other areas back to study villages.

Data show that similar responses to climate extremes are also employed in response to climate variability in both Districts. For example, similar types of storage, livelihood diversification, and communal pooling responses are used (Table 6.6). At the same time, data show some responses to climate variability used in both study districts are not used in response to climate extremes, for example, accumulating resources, joining groups and mobility. This is because climate variability invokes both reactive and active responses, whereas the responses to climate extremes tend to be reactive, i.e. after the event.

Climate variability has invoked a range of responses across different categories, regardless of the nature of variability. These general responses are also used to respond to non-climatic pressures and opportunities. It is therefore difficult to isolate climate variability as the only factor influencing these responses.

6.3.2.3 Responding to perceived climate changes

Farmers have observed a number of changes in climatic conditions, compared with what they perceive as a normal climate. Some of these changes link past climate extremes and variability. Therefore, it is unsurprising that data show responses to climate changes that are also similar to those associated with climate extremes and variability. These are general responses, i.e. they are not specific to a particular type of climate hazard and they are used to respond to other non-climatic pressures and opportunities.

General responses fit into five of the six livelihood adaptation categories: storage, livelihood diversification, communal pooling, market exchanges, and mobility. Some of the modifications, i.e. changes in agricultural management practices, can also be classified as general responses, for example planting food security crops, whereas others are specific to the hazard, such as changing planting dates in response to changes in the onset of rainfall. Results suggest that the nature of the hazard may be important in determining the nature of the response to changing climatic conditions.

Data highlight that farmers in the two study districts are responding to climate changes in different ways. In Soroti District farmers are responding through livelihood diversification strategies and modification, this includes starting new businesses, cultivating cash crops and diversifying the range of crops. As one farmer explained:

> *"When this rain comes you begin planting blindly, you put the millet, then groundnut, then cassava in August. But now seen as you don't know if this rain is going to come at this particular time, you will have to plant all of those crops because you can't estimate".*

(Female Respondent, Agirigiroi, Soroti District, May 2012)

Farmers in Jinja District are also diversifying their livelihoods, for example, seeking casual work and modifying agricultural practices. However, rather than diversifying the range of crops cultivated, farmers are using intensification and mono-cropping, e.g. sugarcane. This demonstrates that Jinja farmers are changing their agricultural management practices in different ways to Soroti farmers. In addition, Jinja farmers are using mobility and market exchanges to respond to climate changes, more often than farmers in Soroti District. It is important to note that all of the aforementioned responses are influenced by multiple factors, for example, market opportunities and land fragmentation. Details from Case Study 4 (Box 6) and Case Study 5 (Box 7) provides examples of how farmer responses are influenced by climatic and non-climatic factors.

Box 6 Case Study 4 cont….: Patrick, Male Farmer, Agirigiroi Village, Soroti District

Changes in the weather and pests and diseases have become major problems affecting Patrick's yields. In response to this, Patrick cultivates different plots of land, and a range of crops and varieties, including both cash and food crops. His wife also makes locally brewed alcohol to generate household income. Patrick maintains a flexible approach to farming, where each seasons he adapts his farming practices. He decides what to plant and where according to how he expects the seasons to be and the resources to which he has access. For example, if the rains delay, then he will buy vegetable seeds and plant in the low lying areas, though he notes that this requires a lot of money to buy chemical pesticides and time to manage them. If he is expecting heavy rains, then he will cultivate only in the highland areas. His ability to maintain this flexible approach is influenced by his access to land, seeds, and labour. If he doesn't have enough labour at home, then he swaps food or locally brewed alcohol in exchange for human labour and/or an ox plough.

Patrick still uses granaries to store food and seeds for the following season and is cautious about selling too much, *"the way we sell them is important. We only sell when we harvest enough …. but even that selling you don't take too much of it, just some few crops, not too much of it".* Patrick always has a field of cassava that he can rely upon for either food or cash, depending on the market prices and what food he has available. This means that in a normal year, Patrick's family have enough to eat. However, Patrick he is keen to generate more income so that he can get his own oxen, build a permanent house and educate all of his children.

6.3.3 Operationalising adaptive capacity

Findings suggest that some responses are specific to certain types of climate hazard, especially in determining how farmers will modify their agricultural practices. In addition to this, a number of the responses to climate extremes and variability are similar across all of the categories of livelihood adaptation, for example seeking casual work opportunities and undertaking natural resource-based activities. This suggests that these are general responses rather than specific to climate hazards.

Farmers within a village do not always respond in the same way, despite being exposed to the same climate hazards on multiple occasions. This demonstrates that there are multiple factors that influence farmer responses, not just exposure to climate hazards. Building on this, the following section will explore the role of adaptive capacity in shaping farmers' responses. Resources and institutions, both components of adaptive capacity, emerge as important factors. These components of adaptive capacity relate to what a system has to enable it to adapt (Chapter 2).

6.3.3.1 Resources

Resources needed for each livelihood adaptation category were listed and then categorised according to what type of resource they represented (human, physical, social, natural or human). A total for each category was produced to provide insight into the types of resources needed to enable different responses.

Analysis shows similarities and differences in how resources have been operationalised by farmers in Jinja District and Soroti District (Figure 6.2). Farmers in Soroti District draw upon different types of human and social resources. Human capital is relied upon and used when other resources are not available. For example, if farmers have insufficient seeds or other inputs, they will exchange their labour, thus supporting their ability to draw on a variety of responses. This can be contrasted with findings from Jinja District, where financial resources predominantly support farmer responses. In Jinja District farmers would also draw upon financial capital to support livelihood diversification. This demonstrates that a major difference between the study districts is in how different types of human, social and financial resources influence household responses. Such findings provide a nuanced understanding of how resources can shape responses to climate hazards.

Responses were interrogated further to examine the number and range of resources needed for each livelihood adaptation category. In Jinja District (Figure 6.3), communal pooling responses require the lowest level of resources, and in Soroti District (Figure 6.3), storage responses require least resources. Livelihood diversification in Jinja District requires the highest number and the largest range of resources. In Soroti District modifying agricultural practices draws upon the largest number and range of resources.

Farmers in Jinja District described how limited natural resources influence the modification of agricultural practices. Although there were variations between households in Soroti District, overall, natural resources were not consistently described as limiting farmer responses; rather they enabled livelihood diversification and diversification of agricultural management practices. Differences in availability and access to natural resources perhaps explain why farmers in Jinja District and Soroti District are modifying their management practices in different ways.

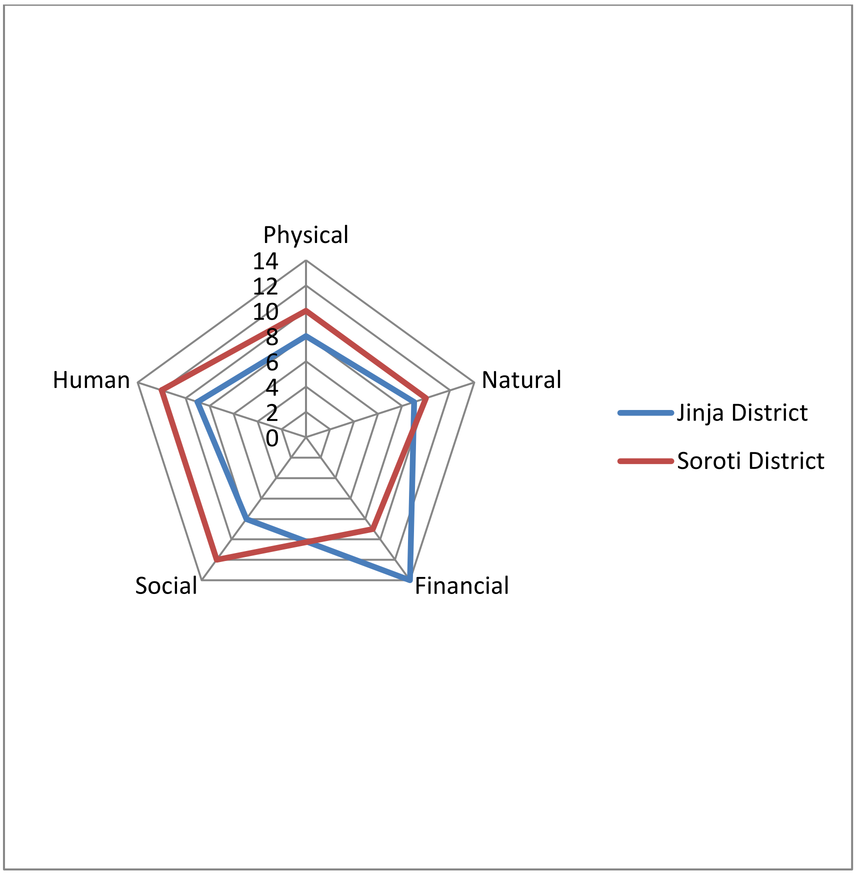
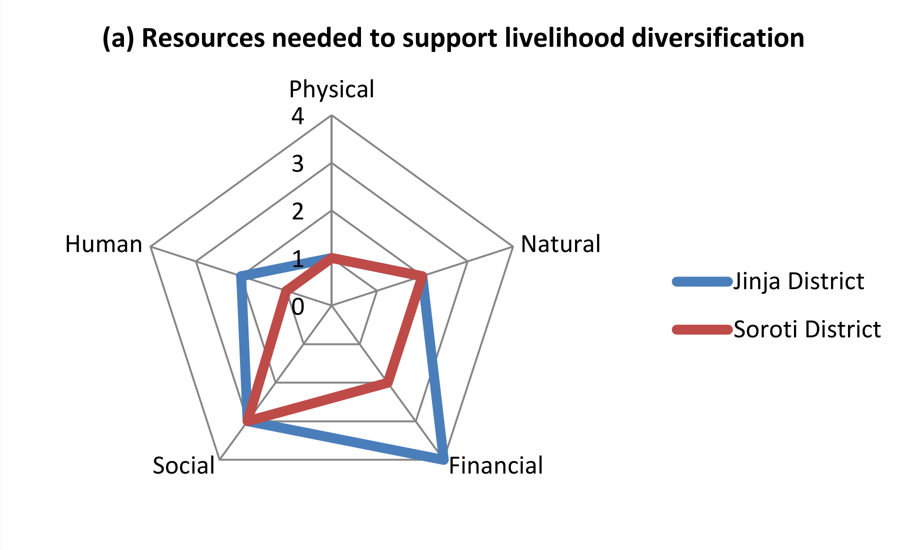
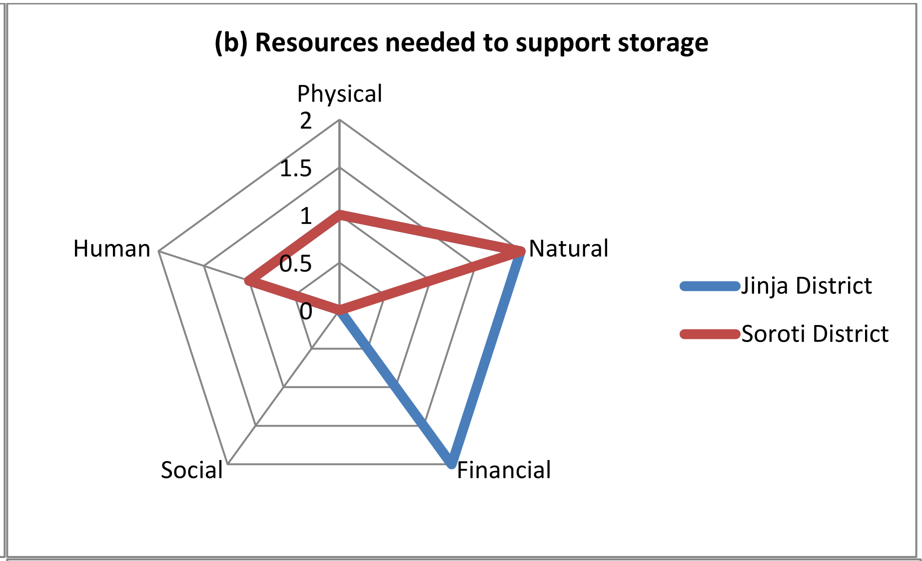


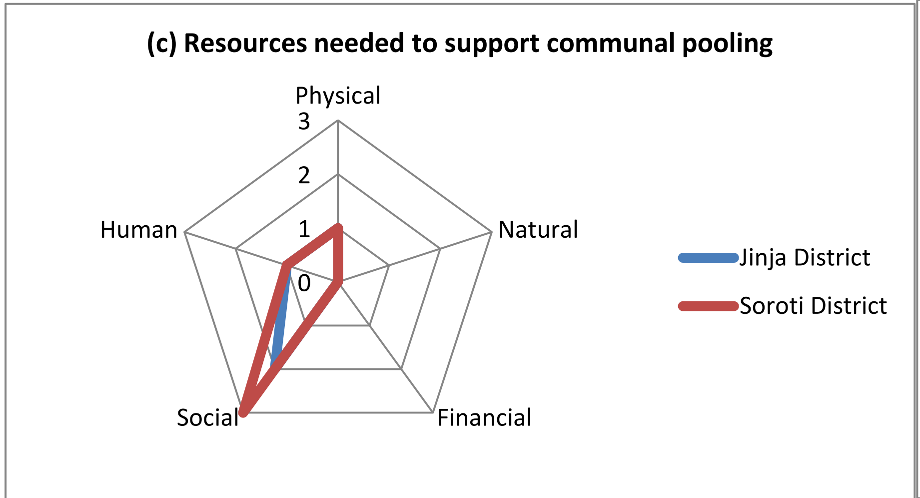
Figure 6.2 Comparison of the range of resources supporting household responses in Jinja District and Soroti District. Scores represent the total for each resource across all of the livelihood adaptation categories.



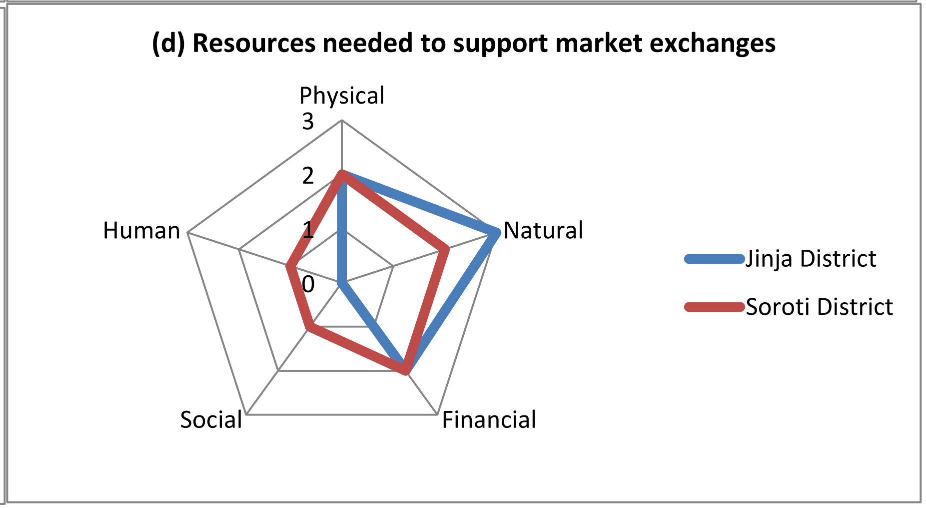
(a) Resources needed to support livelihood diversification
Physical
4
3
2
1
0
Human
Natural
Social
Financial
Jinja District
Soroti District



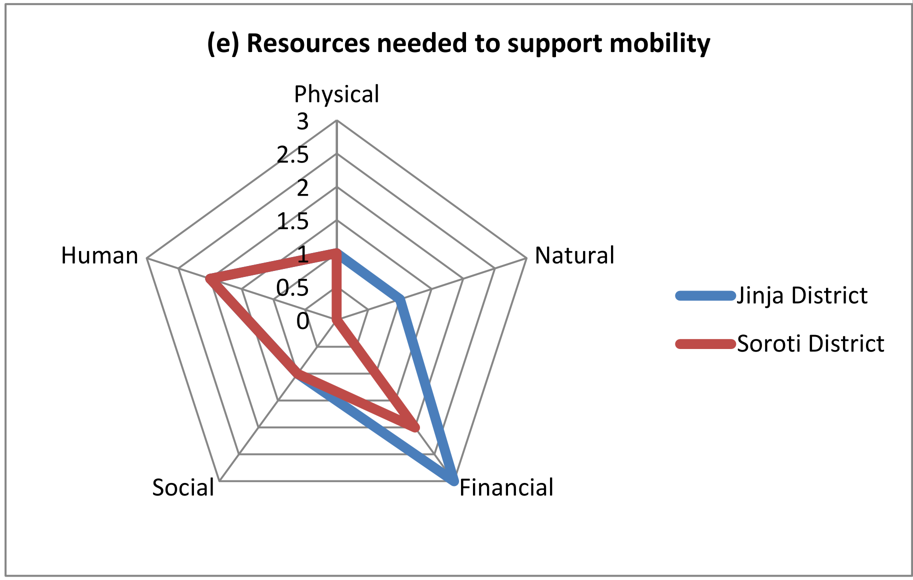
(b) Resources needed to support storage
Physical
2
1.5
1
0.5
0
Human
Natural
Social
Financial
Jinja District
Soroti District



(c) Resources needed to support communal pooling
Physical
3
2
1
0
Human
Natural
Social
Financial
Jinja District
Soroti District



(d) Resources needed to support market exchanges
Physical
3
2
1
0
Human
Natural
Social
Financial
Jinja District
Soroti District



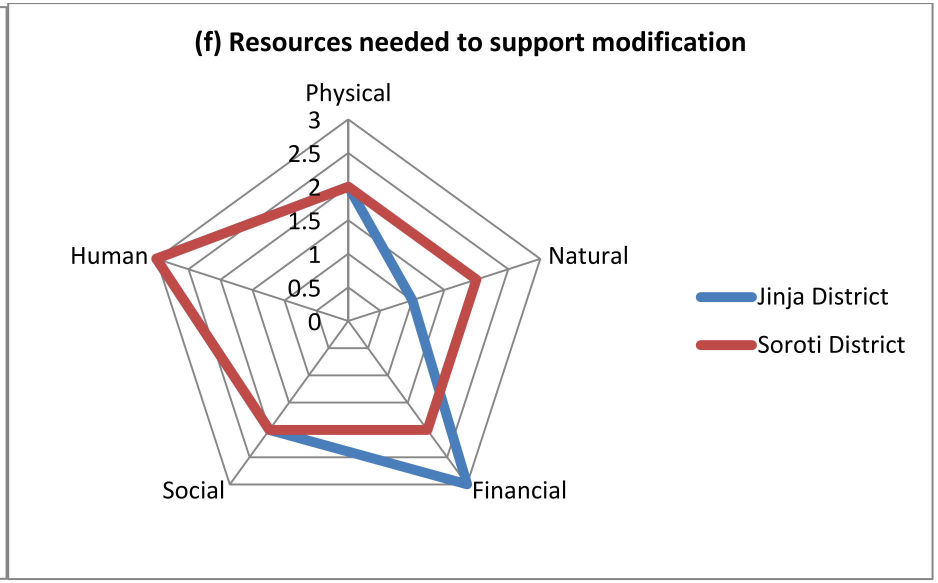


Figure 6.3 (a-f) Overview of the resources that support different household responses for both Jinja District and Soroti District Scores calculated by categorising the resources households needed for each response.

Actual responses depend on the household level asset portfolio and the ability of households to switch between and substitute resources. Farmers who have access to a range of resources, indicated by diversity, or are able to switch between them (requiring flexibility) have more response options. Yet, farmers described how resource access and utilisation at the household level was influenced by a range of institutions operating across spatial scales.

6.3.3.2 Interplay between institutions and resources

This section explores how components of adaptive capacity, i.e. resources and institutions, interact to determine farmer responses. Data from each study district, disaggregated by strategy, provides some important insights into the relationship between resources and institutions and how they influence farmer responses. A summary of the institutions that shape resource access and utilisation for specific responses is provided in Table 6.7. Market institutions emerge as important institutions in both districts. In Soroti District, access to local markets is important. In Jinja District, ‘middlemen’ act as intermediaries between farmers and markets. Civic institutions, such as locally-held knowledge, emerged as important in Soroti District.

Table 6.7 Summary of key institutions influencing resource use and farmer responses, informal institutions are highlighted in italics.

	Market/Private	**Government/Public**	**Communal/Civic**	**Combination**
Storage	Market opportunities Market access - local markets**/ middlemen*	Access to government support ** Government policies and expenditure	Access to CBOs / NGOs +++ Locally-held knowledge** *Inherited socio-cultural practices* *Gender relations +*	Market regulation Barter system of trading**
Livelihood diversification	Market opportunities Access to markets** Linkages with private sector organisations* Labour market opportunities	Access to government programmes	Access to CBOs / NGOs +++ Religious groups and other formal groups ++ *Family and kinship networks* *Inherited socio-cultural practices* *Reciprocity and Trust*	Market regulation Land Tenure** Existing community level power structures
Communal pooling	-	Access to government programmes	Access to CBOs / NGOs +++ Religious groups and other formal groups *Inherited socio-cultural practices* *Gender relations+* *Reciprocity*	Barter system of trading** Labour exchange Existing community level power structures

	Market/Private	Government/Public	Communal/Civic	Combination
Market Exchanges	Market opportunities Market access - local markets**/ middlemen* Linkages with private sector organisations*	Government policies and expenditure Access to government programmes	Access to NGOs +++ *Inherited socio-cultural practices*** *Gender relations +*	Market regulation Existing community level power structures
Mobility	Market opportunities Labour market opportunities	-	*Family and kinship networks* *Gender relations +* *Reciprocity and Trust*	-
Modification	Market opportunities Market access - local markets**/ middlemen* Linkages with private sector organisations*	Access to government programmes	Access to CBOs / NGOs +++ Other formal groups ++ *Family and kinship networks* *Locally-held knowledge** and experience* *Gender relations +* *Reciprocity***	Barter system of trading** Land Tenure Existing community level power structures

+ Control access to and utilisation of resources; ++ e.g. savings, farmer and women's groups; +++ Community based organisations (CBOs)/ non-governmental organisation (NGO) programmes; *Emerged from Jinja District data only; ** Emerge Soroti District data only

For four out of the six types of livelihood responses there are no differences between the study districts in terms of how institutions shape resource access and utilisation (Table 6.8). However, there are distinct differences between the interaction between institutions and resources in storage and market exchanges responses.

Results show differences between the study Districts in terms of which institutions are linked to specific responses. For example, in Soroti District, farmers described how locally-held knowledge and inherited socio-cultural practices influenced farm-level decisions on whether or not to store or sell resources. In Jinja District, farmers reported that decisions about storage and market exchanges were influenced by market prices and access to markets, middlemen and private sector organisations. The dependence on market exchanges in Jinja District is negatively affecting resource availability at a farm level.

Table 6.8 Overview of the resources and institutions that enable certain response strategies to climate hazards for the study districts. Jinja District issues are highlighted in bold and Soroti District in italics.

	Similarities	Differences
Storage	Range of institutions influencing access to and utilisation of physical, human and natural resources. Social capital is not required for this strategy.	**Financial capital, influenced by a range of institutions, is also important.** *Financial capital is not required*.
Livelihood Diversification	All resources and institutions influence resources and nature of livelihood diversification.	No differences recorded
Communal Pooling	Physical, human and social resources are influenced by public, formal civic institutions. Human and social resources are also influenced by informal civic institutions.	No differences recorded
Market Exchanges	Physical, natural and financial influenced by all institutions. Human capital influenced by public, formal civic institutions and informal civic institutions.	**Human capital is also influenced by market based institutions.** *Social capital is important and is influenced by informal civic institutions.*

	Similarities	Differences
Mobility	Physical and financial resources are influenced by public, private, informal civic institutions. Human capital is shaped by all institutions. Social capital is influenced by informal civic institutions.	No differences recorded
Modification	All resources and institutions influence the nature of modification.	No differences recorded

In both districts farmers highlighted saving and/or storing food as a strategy to respond to climate hazards (Section 6.3.2). In Soroti District storage responses are used more widely than market exchanges. This highlights the strength of socio-cultural, inherited practices. The opposite is true for Jinja District, where due to limited natural resources (e.g. land availability), farmers face constraints which undermine their ability to produce enough food to store. Here, farmers draw upon market exchanges, such as growing cash crops, selling traditional food crops (maize) and buying food to respond to climate hazards. These findings suggest that private institutions, such as market availability and access, have contributed to the erosion of the informal socio-cultural institution of saving crops for food and seeds. As farmers in Jinja District explained:

> *"because of the higher price of maize it has made people not keep maize, but in those days maize was at 100 shillings a kg, but today it is 1000 a kg and people really want to receive that money. So saving sometimes, to keep maize is a problem because of a high price of maize."*

(Female Respondent, Kalugu, Jinja District, 2012).

> *"these days, it's all about economics, in those days people did not bother about wealth, but now the laws of economics make people to know you can't give anything for free".*

(Female Respondent, Kalugu, Jinja District, 2012).

Differences between the use of storage and market exchanges in the study districts can be explained by the ways in which institutions interact with farmer priorities and preferences to influence farmer responses. The findings suggest that there is a potential relationship and substitution between storage responses and market exchanges. However, the shift from storage to market exchanges can negatively impact upon the ability to respond to future climate hazards.

> *"Some families, they don't plan for the future …. they sell everything, then they don't have seeds for the next season. So that is a major issue if you sell everything……then you are not able to cope when the drought comes in."*

(Female Respondent, Kangeta, Soroti District, 2012).

At the same time, market exchanges, e.g. cultivating and selling vegetables and sugarcane, often requires improved varieties, and in some cases, chemical inputs. This shift is undermining the diversity of crops under cultivation and having negative impacts on the both the natural resource base and people's future ability to produce food:

> *"We are looking at how we have cultivated sugarcane, so we have cut all of the trees and that is why we have got a problem of not getting rain on time. As of now, the real concern is sugarcane which has cut trees down and caused lack of rain. Population has increased, in those days the population was very few. You could see lorries parked with charcoal to be used as a result of cutting down trees. That is what has caused the changes in rainfall"*

(Male Respondent, Idoome, Jinja District, 2012).

Institutions shape access to and utilisation of resources in different ways, depending on the type of response. Livelihood diversification and modification strategies in response to climate hazards are influenced by market opportunities (private institution), government policies (public institution) and non-governmental programmes (formal civic institutions) and access to resources, which require physical, social, human, natural and financial resources. Moreover, livelihood diversification involves the ability to transfer or switch between resources, which is also influenced by a range of institutions. Findings from Case Study 5 (Box 7) illustrate some of these issues.

> *"People have found themselves in a certain kind of business. Some people are maybe finding or buying some small fish, then they go and sell. Out of the profits they go and buy food for themselves at home...buy, sell and get some things for home"*

(Male Respondent, Adamasiko, Soroti District 2012).

Findings show that the ways in which resources and institutions interact can enable certain responses, whilst constraining others. Institutions can also influence resource utilisation, by impacting upon farmer decision-making processes, thus indirectly shaping resources over time. Institutions can thus have both direct and indirect impacts on resource access and utilisation.

Box 7 Case Study 5 cont….: Geoffrey & Mary, Farmers, Bukoloti Village, Jinja District

With 2 wives and 18 children, Geoffrey has struggled to support them all due to insufficient land, low yields and fluctuating market prices. He used to rely on agriculture as his only source of income, but in recent years has looked for other ways of generating income, for example by providing casual work on sugarcane fields or looking for work in the nearby trading centres. Since Geoffrey has expanded his income generating activities, he has built a permanent house, bought more land and sent his children to school. At the same time, he is still worried about how the changes in weather and market prices will affect his ability to provide food in the future, as well as meet other household needs.

Geoffrey recognizes that not everyone in the village has been able to cope with the changes in weather, for example he explained how some people do not have enough land to cultivate different crops and that these people are badly affected when the weather changes. Many households have also switched to sugarcane, and are therefore are not producing enough food crops. If the weather conditions are bad, for example the rains are delayed, then people are reliant on buying food. Some people don't have money as they are waiting for cash from their sugarcane harvest. In the long term, this means that households may not have the necessary resources for cultivating future food crops. For these reasons he believes that food insecurity is increasing in Bukolokoti.

6.4 Discussion

In this discussion, findings from Uganda are used to explore how farmers have responded to past climate hazards to provide insight into how response capacity, or latent adaptive capacity has been operationalised in practice. This data is then used to critically examine the relationship between exposure and adaptive capacity. Following this, ways to better support farmers to respond to future climate hazards are identified. In line with Giller (2013), rather than develop prescriptive recommendations, this chapter highlights important principles for enhancing adaptive capacity, specifically, the importance of flexibility, diversity and learning.

6.4.1 Responding to climate hazards: operationalising adaptive capacity

Data presented in this chapter confirm that farmers in both study districts have been exposed to a range climate hazards. As with Roncoli et al. (2001), farmers' accounts largely converge with secondary data, thus verifying farmers' ability to recall and describe climate hazards. Disparities between primary and secondary data can be explained by multiple factors operating at an individual level, including memory heuristics, risk perception and behaviour change (Marx et al., 2007). The recency heuristic explains how recent events may influence farmer perceptions of past events and their ability to remember (Marx et al., 2007). Findings further highlight that farmer perceptions of hazards can be influenced by the impacts of the hazard, leading to different experiences of the same type of hazards. This demonstrates that it is difficult to separate exposure to a hazard from the impacts that occurred, and links to sensitivity and capacity to respond to the hazard (Simelton et al., 2013). These findings are in line with what Simelton et al. (2013) describe as the difference between perceived and observed exposure. These differences can result in multiple conceptualizations of climate hazards such as droughts, which are not necessarily linked to meteorological or agronomic definitions. These differences suggest a more complex relationship between exposure, sensitivity, adaptive capacity and impacts than is presented by the framing of vulnerability in the climate change literature. More work is needed to understand these relationships and the implications for adaptation to future climate change and variability.

Analysis highlights differences between how individual farm households are responding to climate hazards within the same study district. Differences can be explained by variations in access to resources at a household level. The influence of household-level resource access in shaping farmers' response capacities is consistent with other studies that highlight the importance of land (Simelton et al., 2009) and social capital (Deressa et al., 2009). Resource access and utilisation is mediated by interacting market, civic and public institutions operating across spatial scales. Other studies demonstrate the importance of social and individual factors (Jones and Boyd, 2011), belief systems, psychological factors and cognitive processes in determining the ability of farmers to translate response capacity into action (Grothmann and Patt, 2005). However, these factors remain underexplored in this study.

The biggest difference that emerged from this study was the way in which households modify their agricultural practices in response to climate hazards. This varies both within and across study districts, highlighting the context-specific nature of adaptation (Vincent et al., 2013). Strengthening adaptive capacity requires consideration of how household-level decision-making influences resources, institutions, productivity and diversity at the farm-level (Dixon et al., 2014). There is also potential to further examine decision-making processes at both a household and individual level, for example why some farmers do not act, thus shedding light on the barriers to operationalising adaptive capacity (Bryan et al., 2009). Such research at an individual or household level would provide insight into the range of factors that influence farmer decision-making and behaviour. This could inform future research and policy priorities and result in better targeted adaptation support.

The way that institutions interact across spatial scales can lead to unequal resource access within a geographical area. This can exclude certain groups or individuals, resulting in unequal distribution of costs and benefits (Adger et al., 2006), thus creating winners and losers (Leichenko and O'Brien, 2006). Winners in this context are able to benefit through exposure to climate hazards. Losers are either unable to respond or their responses are maladaptive, i.e. they are undermining future adaptive capacity. Understanding such differences requires exploration of institutions operating across spatial scales, including exploration of intra-household dynamics, and how they shape decisions about modification at the household level (Deressa et al., 2009). Such research would provide insight into how institutions interact to create winners and losers, and is thus an important first step in creating inclusive institutions and better enabling farm households to respond to climate hazards.

6.4.2 Exposure to climate hazards and adaptive capacity

Exposure to past climate hazards also influences adaptive capacity at the household level in a number of ways. In addition to climate hazards, a range of other institutional factors shape access and utilisation of resources, and therefore adaptive capacity. This confirms that climate hazards cannot be isolated from the institutional context in which exposure to the hazard is taking place (Berman et al., 2012). Future studies of adaptation to climate hazards should focus on the role of institutions in shaping how resources are accessed and utilised (Wang et al., 2013, Agrawal, 2008, Adger, 2003). Understanding these dynamics could enable the identification of areas where institutional change is required to foster adaptive capacity at the household level. This could increase resilience and reduce vulnerability of households to future climate hazards.

Findings presented in this chapter confirm that household-level responses to climate hazards depend on the nature of hazard and the level of adaptive capacity, i.e. the amount and range of resources and the institutions that mediate resource access and utilisation (Scoones, 1998). Exposure to climate hazards can strengthen or maintain adaptive capacity, depending on the impact that the response has on future resource access and utilisation, highlighting important temporal dimensions. For example, if the response means that households continue to have access to a range of resources or increase the amount or range of resources, then the response to the climate hazards has had a neutral or positive impact on future adaptive capacity. In this chapter, the temporal dimensions of adaptive capacity are underexplored and warrant further investigation.

Farmers in Soroti District have historically been exposed to a greater number and more diverse range of climate hazards compared with farmers in Jinja District. However, farmers in Jinja District described an increase in exposure to climate hazards in the last 5 years. The perception of increased exposure combined with a dependence on a narrower range of resources (e.g. land) and livelihood activities (market exchanges) has resulted in increasing levels of food insecurity. Farmers also refer to this increase in food security as a ‘drought’. In these instances, farmers are describing an ‘access drought’, where climate impacts are associated with resource dependency (Simelton et al., 2013), i.e. a narrow range of resources which undermines the ability of farmers to respond. Evidence suggests that if certain resources are limited, e.g. land, then farmers’ abilities to switch between resources demonstrates their adaptive capacity. For example, in the absence of other resources, farmers are able to draw upon social or financial resources to enable a response; such findings concur with Simelton et al. (2009) and Fraser and Stringer (2009). This suggests that flexibility is important in understanding the relationship between exposure and adaptive capacity. Maintaining or increasing flexibility may provide a further link between vulnerability and resilience.

In Jinja District flexibility is being undermined by the erosion of traditional practices and shifts towards market-oriented agriculture. This is resulting in increasing food insecurity at the household level. As Coulthard (2008) suggests, it may not be poorest who are the most vulnerable to climate hazards, it may be those locked in to inflexible systems. In the case of the Jinja farmers, economic and institutional drivers are creating an inflexible farming system. This highlights that transitioning to market-oriented agriculture can undermine the flexibility of the farming system. Lack of flexibility is reducing adaptive capacity and reducing the range of response options that households have; thus undermining the ability of households to respond to both climatic and non-climatic hazards. This reduction in household response options is thus increasing the susceptibility of households to be harmed by future climate hazards, i.e. it is increasing vulnerability. These findings are similar to other work on the importance of response diversity in maintaining ecosystem resilience (Mori et al., 2013, Elmqvist et al., 2003) and ensuring sustainability of farming systems (Kremen et al., 2012). This demonstrates that flexibility is an important determinant of both resilience and vulnerability and should therefore be considered in future adaptive capacity assessments.

The Jinja District case study demonstrates that institutions can operate in a manner that reduces the flexibility of resource access and utilisation over time by undermining diversity at the farm-level. Given that exposure to climate hazards in Uganda is expected to increase, enabling a range of responses will be important so as not to lock farmers in to rigid farming systems (Wilson, 2013).

Results also demonstrate that in Jinja District farmers are dependent on fewer resources and a narrower range of activities at the household level, i.e. diversity at the farm-level is being reduced. This is again reducing response options and locking farmers into inflexible systems of farming. This could further undermine the ability of households to respond to future climatic and non-climatic hazards, reducing their level of adaptive capacity. Promoting diversity at the farm-level is a way to maintain or strengthen flexibility, and thus adaptive capacity over time (Dixon et al., 2014, Thornton et al., 2007). Ensuring access to a diverse range of resources provides a way for farmers to deal with uncertainties surrounding future climatic and non-climatic conditions. Yet the drivers, barriers to and benefits of farm-level diversity are not fully understood. More research is needed to understand the outcomes of maintaining or increasing diversity on poverty reduction, well-being and socio-economic development.

Diversity can also be explored at a farm-level and include consideration of activities and resources (Goulden et al., 2013). This chapter has demonstrated the importance of how adaptations undertaken at the farm-level can influence future diversity as a component of adaptive capacity. Policies and programmes should promote the importance of diversity and foster on-farm diversity, in terms of access to resources and the types of activities promoted. Developing, monitoring and applying Indicators of diversity to new and existing policies and programmes could provide one way to support smallholder farmers adapt to future climatic hazards.

Current assessments of adaptive capacity tend to be static, and thus overlook the temporal dynamics of diversity and its relationship with flexibility. Findings presented in this chapter suggest that flexibility is an important system property that could be included to advance part of the original FSAC framework (Figure 2.2) to Figure 6.5.

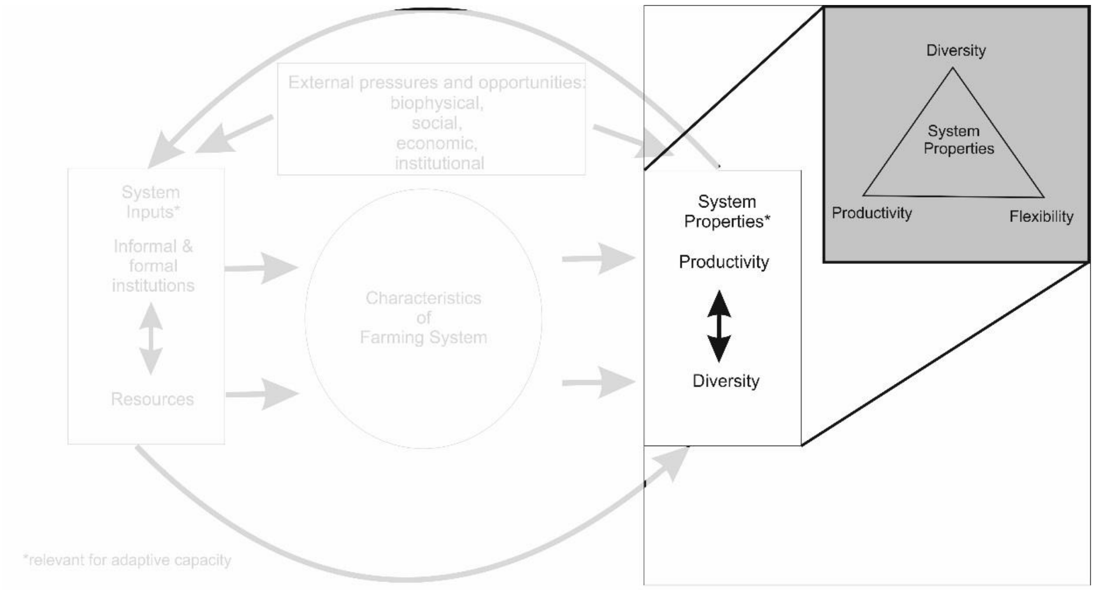


Figure 6.4 Illustration of how the 'system properties' component of the Farming System Adaptive Capacity framework (Figure 2.2) has been advanced by chapter findings. Modification highlighted in grey.

6.5 Summary of Chapter 6

Historically, farmers in Soroti District have responded to more frequent and a wider range of climate hazards than farmers in Jinja District. However, over the last 5 years, farmers in both districts observed changes in climate patterns. This implies that exposure to climate hazards is increasing in Jinja District. Farmers in Jinja District are responding using market exchanges. An increasing dependence on market exchanges is reducing the diversity of crops under cultivation in Jinja District, which is having negative impacts on the both the natural resource base and the future ability of households to produce food.

Adaptive capacity will be important in determining how farmers respond to future climate hazards, and therefore the actual impacts of future climate change. However, farm households possess different levels of adaptive capacity, depending on resources and the institutions that shape how resources are accessed and utilised. Variations in levels of adaptive capacity demonstrate that individual farm households respond in different ways when exposed to climate hazards. Despite differences between how individual farm households draw upon adaptive capacity to enable certain responses, similarities between farmer responses within a district exist. In addition to similarities within districts, a number of differences between districts were identified, thus suggesting that targeted support should be tailored to take into account the resource base and institutional context within geographical areas.

Through the use of empirical data, this chapter also provides a nuanced understanding of the relationship between exposure and adaptive capacity. Findings confirm that it is difficult to separate exposure to a hazard from the impacts that occurred, which links to sensitivity and capacity to respond to the hazard (Simelton et al., 2013). Therefore, this thesis highlights a more complex relationship between exposure, sensitivity, adaptive capacity and impacts than is suggested by the framing of vulnerability in the climate change literature. In line with resilience thinking, exposure to climate hazards, i.e. perturbations, can contribute to the resource component of adaptive capacity as long as flexibility or diversity at the farm-level is maintained.

Chapter 7 How will farmers adapt to 2030s rainfall scenarios? Convergence and divergence between policy and practice

Abstract

This chapter examines autonomous agricultural adaptations to 2030s' rainfall scenarios and assesses the extent to which such adaptations are supported by current policy (Objective 3). Using future rainfall projections for Uganda in the 2030s and participatory methods, this chapter explores farm-level autonomous agricultural adaptations. Agricultural adaptations represent one of the specific livelihood adaptations categories used in Chapter 6 (Wang et al., 2013), which were identified as an important area for further research in Chapter 6; thus justifying the focus of this chapter. Primary data from semi-structured interviews with farmers and policy stakeholders are combined with a policy analysis to identify areas of convergence and divergence between policy support and autonomous adaptations to 2030s' rainfall projections. This also builds on understanding of the role of formal institutions (policies) in shaping farming and adaptation, identified as important in both Chapter 5 and Chapter 6. The present chapter therefore provides additional insights into adaptation planning priorities needed to support smallholder farming and adaptation in the context of climate change and variability.

Findings suggest agricultural adaptations in response to 2030s' rainfall scenarios will vary depending on the nature of the farm system, such as the extent to which it is subsistence or market oriented, and access to resources such as land and labour, and availability of income. Current agricultural policy supports specialization and intensification strategies, yet such support could exclude farmers who use other strategies such as diversification; thus creating winners and losers. This demonstrates important interplay between agriculture and adaptation policies and practices, suggesting that adaptation should be better integrated into agricultural policies. Moreover, to support farmers to adapt to uncertainties of future climate changes, agricultural policies, which currently focus on intensification and specialisation as ways to achieve agricultural modernisation, should better support diversification and extensification. Supporting a wider range of autonomous adaptation options could foster response diversity, and thus avoid lock-in to inflexible systems of farming.

7.1 Introduction to Chapter 7

Minimising the impacts of expected rainfall changes in the 2030s may require smallholder farmers to adapt their agricultural practices. Studies of local-level adaptation (Wang et al., 2013, Agrawal, 2008), as well as the adaptations considered in Chapter 6, tend to focus broadly on livelihoods, highlighting a gap in studies that specifically focus on on-farm adaptations. As Chapter 6 demonstrates, modifications to agricultural practices vary between households. This highlights a need for studies that specifically focus on agricultural adaptations, which can be further broken down into extensification, intensification, specialisation and diversification. Using data gathered using participatory methods during semi-structured interviews, this chapter focuses on how farmers would modify their agricultural practices in response to 2030s' rainfall scenarios (Objective 3). Specifically, this chapter focuses on rainfall-related pressures and opportunities component of the FSAC framework (Figure 2.2), and what inputs and properties shape these responses. It therefore examines connections between pressures and opportunities, system inputs, adaptation, and system properties components of the FSAC framework (Figure 2.2). By addressing this gap, it provides a nuanced understanding of the nature of on-farm agricultural adaptations.

Despite a plethora of case studies into adaptation at the local level, few studies examine the kinds of adaptations that are supported and promoted by adaptation policies. Yet, policies have been identified as being able to both undermine and support adaptation efforts (Stringer et al., 2009). Moreover, adaptation cuts across a range a sectors, but it is unclear to what extent adaptation policies have been mainstreamed into existing policies or how adaptation policies interact with other policies in specific sectors, such as agricultural policies. This chapter addresses this by identifying areas of convergence and divergence between different policies. It provides insight into which agricultural practices are being supported by policies and who policy is supporting. These are important considerations for the justice and fairness of adaptation (Adger et al., 2006).

The overall aim of the chapter is to assess how policies can support and hinder agricultural adaptations to 2030s' rainfall scenarios in Uganda (Objective 3). Together findings from this chapter are integrated with evidence presented in Chapter 5 and Chapter 6 to advance understanding about smallholder farming and adaptation in the context of climate change and variability, and thus contribute to the overall research aim. This chapter also highlights key insights from integrating science, policy and practice and includes recommendations for how policy could better support farmers to adapt to future climate changes.

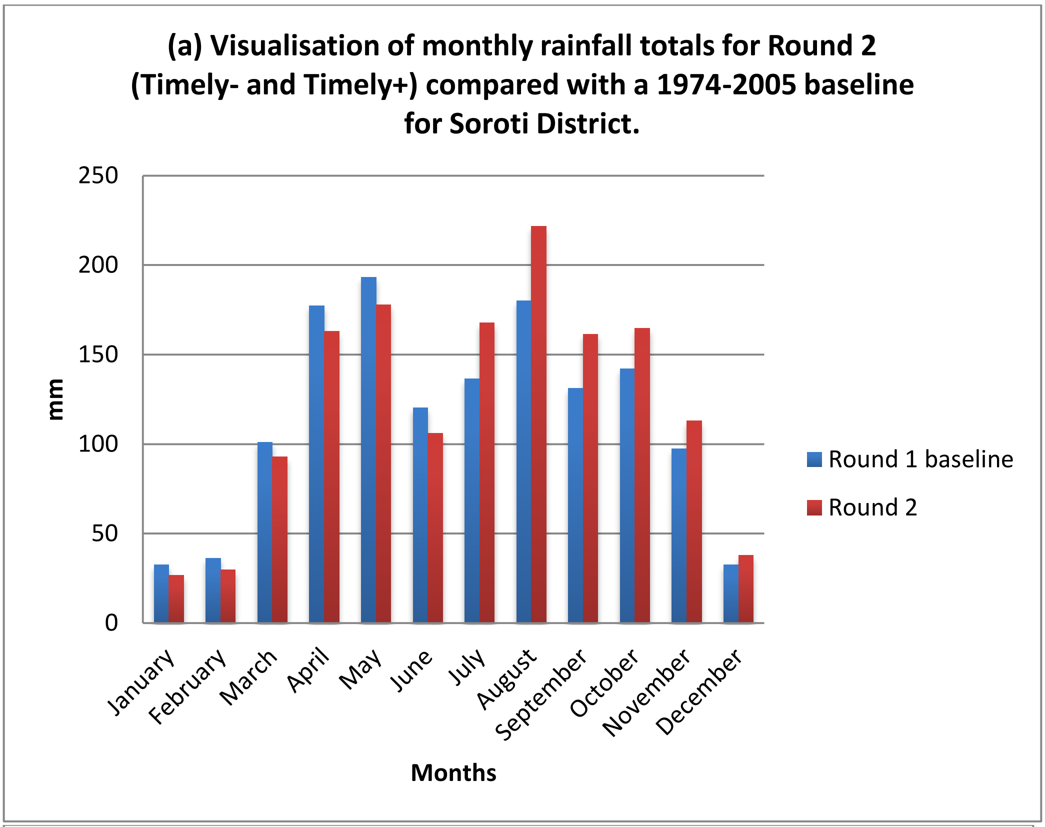
7.2 Research design, methods and analysis

This chapter combined semi-structured interviews involving rainfall calendars and seasonal calendars with policy analysis of national policy documents, which included selected agriculture, adaptation and development policies. Summarising from Section 2.8.2, the main adaptation strategies that are considered in this chapter are: 1) extensification (expanding the size of the area in which agricultural is undertaken; decreasing the land to crop/livestock ratio); 2) intensification (reducing the size of the area; spending longer or working harder on the activity to maintain the same returns; increasing the ratio of crops/livestock to land); 3) diversification (increasing the range of agricultural activities, crops, livestock; or adding crops or livestock whilst retaining the previous ones); and 4) specialisation (reducing the range of agricultural activities, crops, livestock, or replacing them with fewer crops, livestock and agricultural activities).

7.2.1 Semi-structured interviews

Autonomous agricultural responses were elicited using participatory rainfall and seasonal calendars used during semi-structured interviews (Section 4.3.8). The process of developing the rainfall projections is set out in Section 4.3.9.2. Rainfall projections were turned into scenarios, referred to as Delayed+, Delayed-, Timely+ and Timely-, to capture the characteristics of the rainfall (full descriptions are provided in Table 4.5). The scenarios, including a baseline, were divided into three rounds. Baseline rainfall conditions for each month were communicated to farmers in the first round. Scenarios Timely+ and Timely- were communicated to farmers in the second round. Scenarios Delayed+ and Delayed- were communicated in the third round.

Each rainfall scenario represented a season. Rainfall totals for each month of the season were calculated using a baseline and projected monthly rainfall totals for 2030s (more about this process is provided in Section 4.3.9.2). Monthly totals were then communicated to farmers on a month-by-month basis. The amount of rainfall (mm) was given to farmers using a bar-chart drawn on a chalkboard and verbally described in comparison with normal baseline rainfall conditions expected for that month. Visualisations of the data presented to farmers are provided in Figure 7.1 for Soroti District and Figure 7.2 for Jinja District.



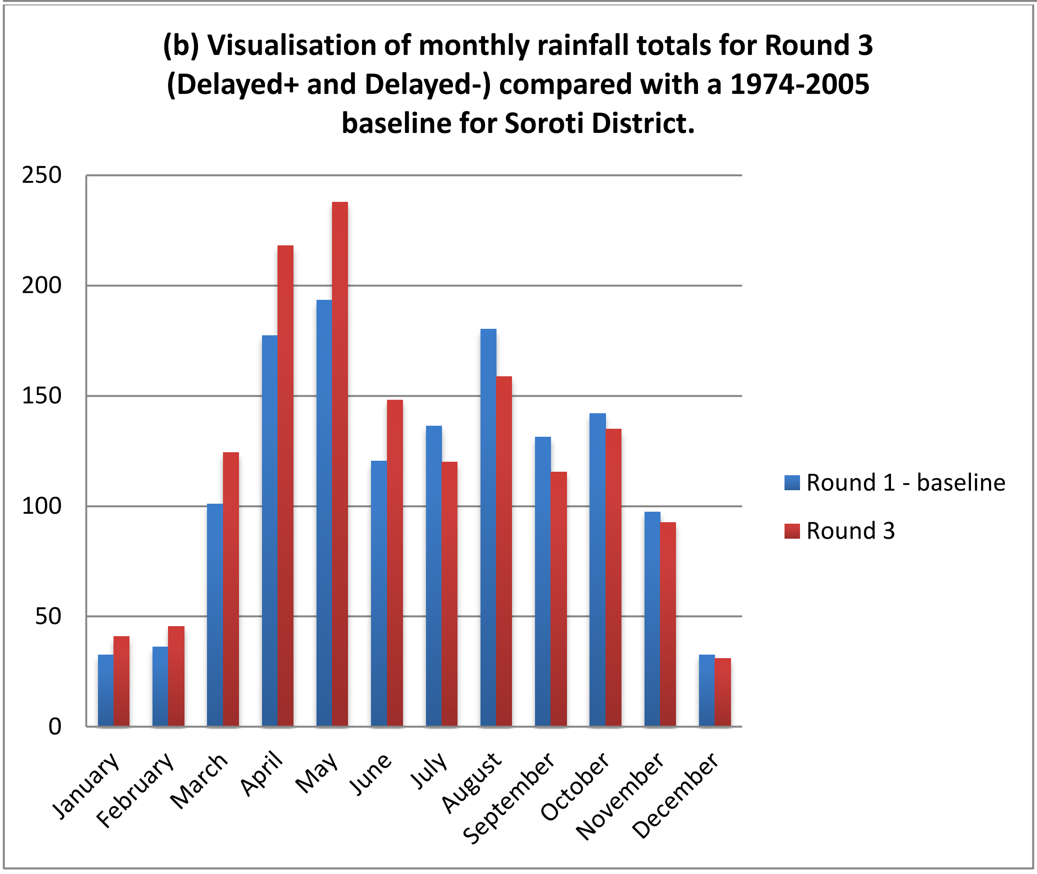
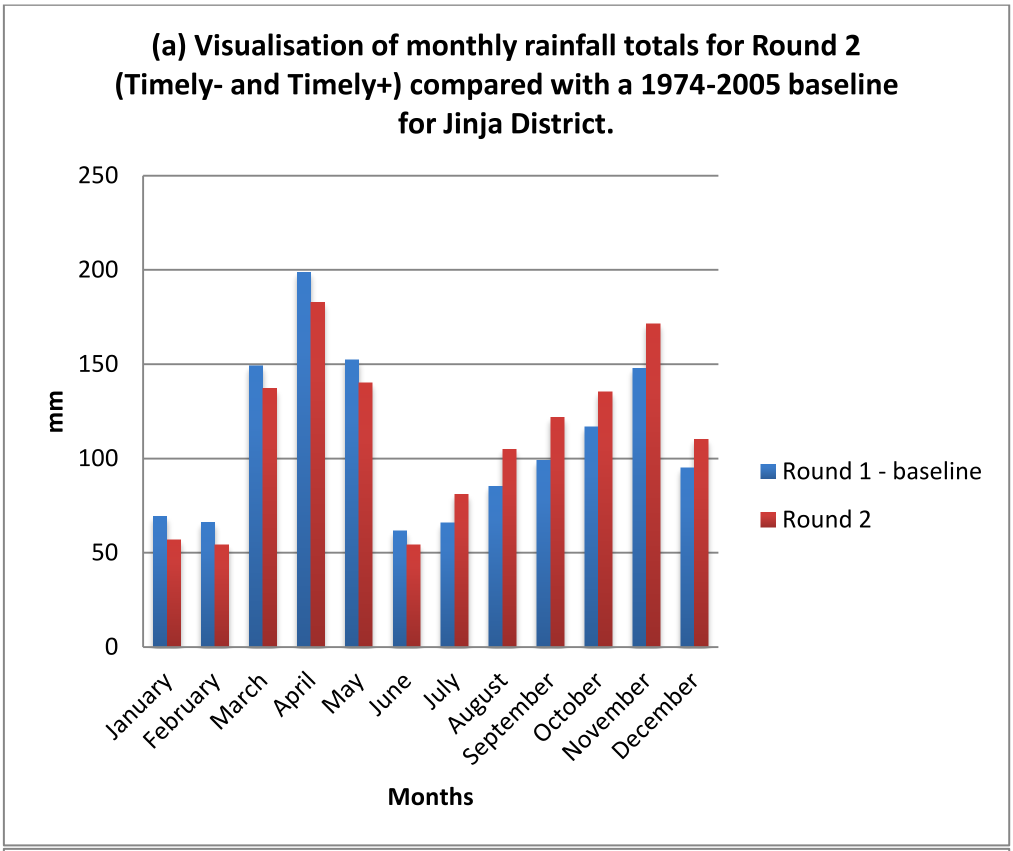


Figure 7.1 Visualisations of monthly rainfall totals communicated to farmers in Soroti District.



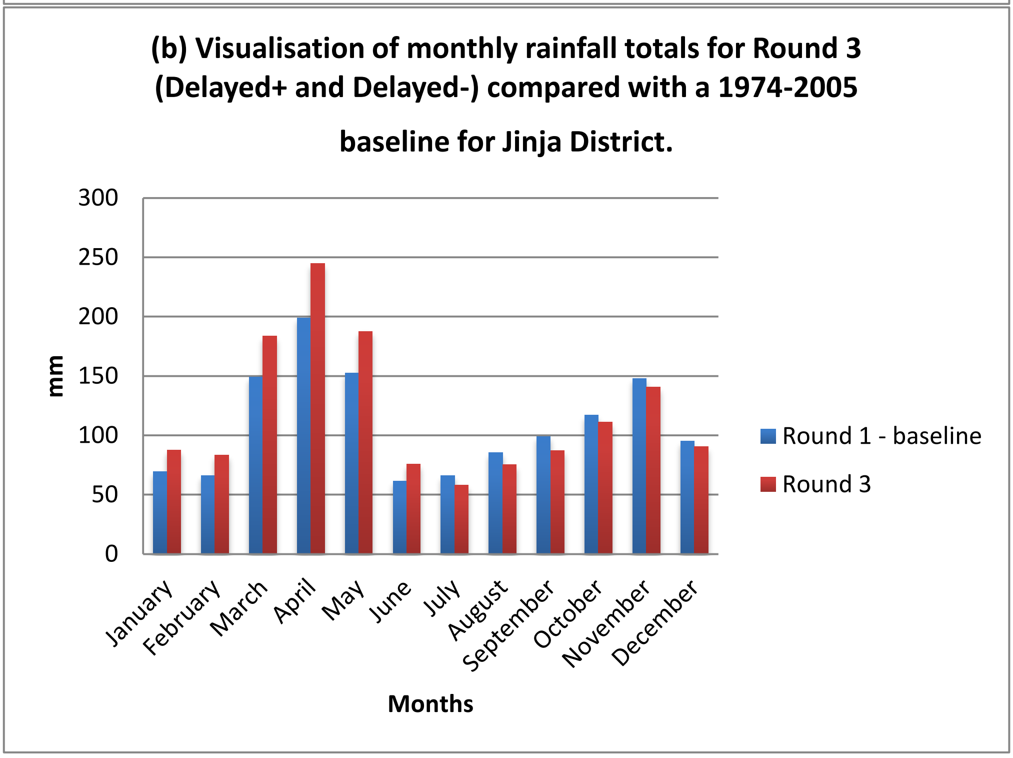


Figure 7.2 Visualisations of monthly rainfall totals communicated to farmers in Jinja District.

After the rainfall amount was given to farmers, they were asked a series of questions related to what they would do, if anything, in response to the expected monthly rainfall total. Questions were devised to represent different stages of a growing season and to reflect the types of decisions farmers make throughout the season. A range of sub-questions were also asked to explore farmers responses in more details, including other factors that could affect famer decision-making.

Table 7.1 Example questions that farmers were asked after the rainfall amount was given for each month

Stages	Main questions	Sub questions (if answered yes to main question)
Preparations	Would you prepare any gardens? Why / why not?	How much land would you prepare? Where is the land? Why?
Planting	Would you plant any crops? Why / why not?	Which crops? Where would you plant them? Why?
Management	Would you need to manage any crops? Why / why not?	Would you need to apply fertiliser, pesticides, weeding? Why?
Harvesting	Would you harvest any crops? Why / why not?	Which crops? Why? How would you score the harvest on a scale of 1-5 (high – low)? Why?
Post harvesting	Would you do anything with the harvest? Why / why not?	What would you do with the harvest? Why? Where would you sell / store it?

Farmer responses to the monthly rainfall information and the broader discussions were captured using seasonal calendars (Section 4.3.8.3). An example is provided in Figure 7.3. As outlined in 4.4.2, qualitative data from seasonal calendars were coded to determine the nature of agricultural adaptations (Saldaña, 2009) and also to identify factors influencing farmer decision-making at different points in the season.

Year 2, Round 1				Land Size (acres): 3.5						3.5 – ALL OF IT. They rented 4.5 from neighbour (it turns out they intend to rent this and plant it – it's a future plan)									CODE: ADM201		
Season	Crop/ Cultivar	Location	Pesticide used Y/N	Fertilser use Y/N	% of cultivated area 1st/ 2nd season		Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Yield Evaluation		Explanation of yield evaluation
B	MAIZE – IMPROVED – NALONGE 5	H	N	Y	1	1			OOO	V	X*	V	V	H OOO	V	V**	X**	X****	2	3	1st season – wife says hig, husband says low – wife thought there was enough rain, husband said there was a lot of sunshine. Husband explained to wife then they agreed on low 2nd season – the rains dropped in November – the maize didn't get enough water
2	SORGHUM – LOCAL VARIETY	H	N	N	X	>0.5	X	X	X	X	X	X	OOO	V	V	X	H	H	X	4	Local sorghum doesn't need too much rainfall
1	MILLET - local	H	N	N	0.5	X			OOO	V	X*	X*	H	ST	X	X	X	X	3	X	Millet is a bit resistant but it needs a lot of rain in may when it has heads
2	SORGHUM – NILE BREWERIES	L	N	N	X	0.5	X	X	X	X	X	X		OOO	V	X	X	H	X	4	

- *FINISHED WEEDING SO NOTHING TO DO
- MILLET WEEDED ONLY ONCE
- ** HUSBAND SAID IT BUT WIFE AGREED
- **** husband says harvest but wife says that maize needs to be left longer to dry because of rains in November 'leave it in garden to dry properly'. The husband agrees it need to be left to dry
- May – nothing to do as weeding finished – millet only weeded once.

Figure 7.3 Example seasonal calendar from a semi-structured interview in Jinja District.

Adaptations were categorized into the extent to which they represented intensification, specialization, extensification and /or diversification (Section 2.8.2). They were then counted and analysed to identify patterns. Initially, farmers were divided according to the number of changes they would undertake. The maximum number of possible changes throughout the season was 52, however the minimum number of changes was 11 and the maximum was 35. This created two groups: the first included farmers making less than 20 changes, and the second group comprised those making more than 20 changes. Farmers were then further divided according to the nature of the production system (Figure 7.4).

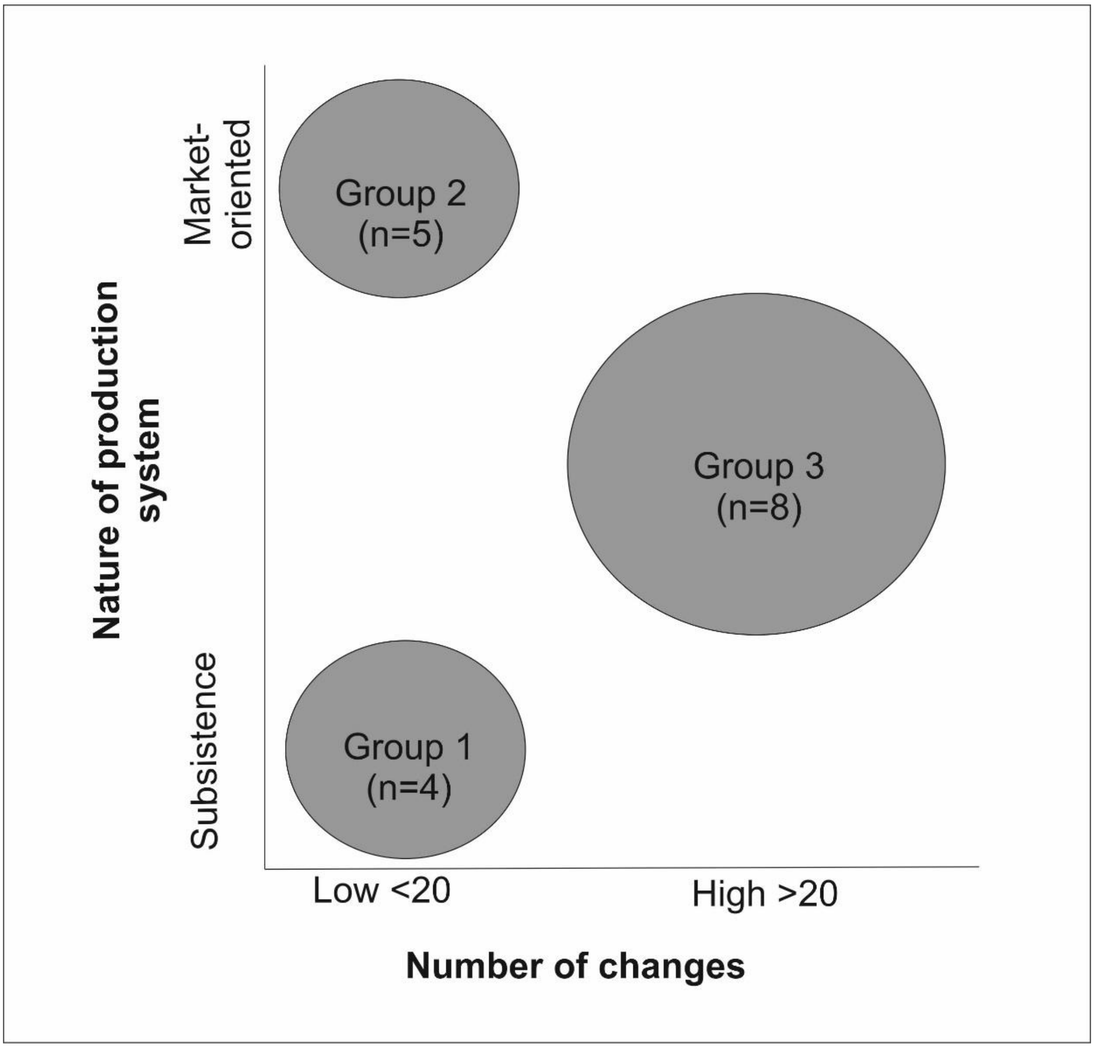


Figure 7.4 Results from grouping farmers according to the number of changes and nature of production system . Circles are different sizes to represent difference in the size of the different groups.

Group 1 made the lowest number of changes (less than 15 out of 52) and was made up of subsistence oriented farmers. Group 2 comprised farmers who made few changes (less than 20 out of 52), but were market-oriented. The third group comprised farmers who made more than 20 changes and cultivated for a combination of subsistence and market purposes. However, during qualitative analysis of the data, differences emerged between farmers in Group 3 according to their access to land. Therefore, farmers in Group 3 were split into two groups (Adapters+ and Adapters-) according to access to land (Figure 7.5). Names were given to each group to characterise how they responded to the scenarios. Characteristics of the groups are described in Table 7.2.

Table 7.2 Names and description of farmer groups.

	Name	Description
Group 1	Maintainers	Low number of adaptations, with limited access to land (<1 acre).
Group 2	Entrepreneurs	Low number of adaptations, but able to access (rent) additional land.
Group 3	Adapters+	High number of adaptations, with access to large plots of land.
Group 4	Adapters-	High number of adaptations, but limited access to land (<2 acres).

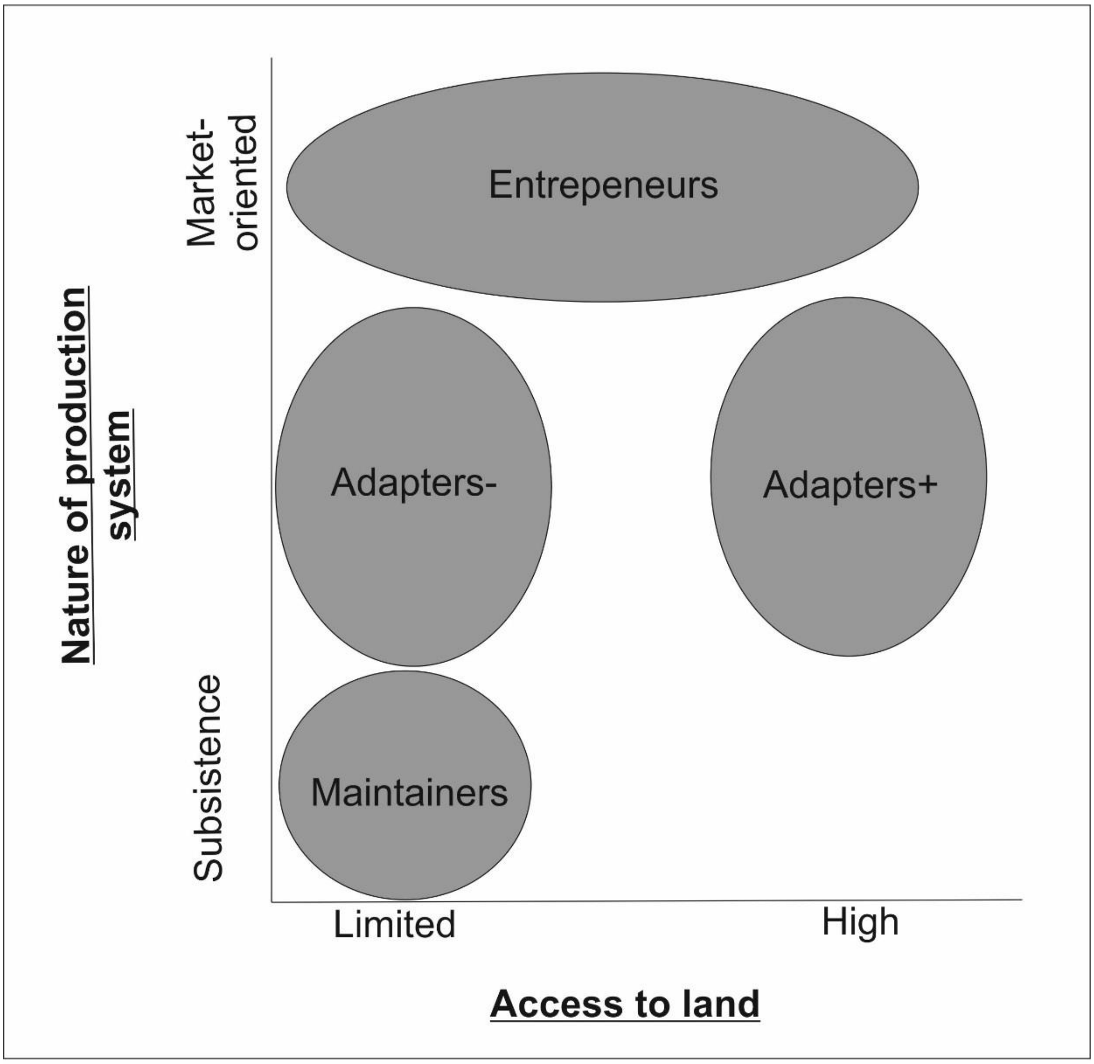


Figure 7.5 Results from grouping farmers according to the number of changes, nature of production system and access to land. Circles are different sizes to represent the nature of the production system and land access, they are not proportional to the size of the groups.

Additionally, semi-structured interviews with sub-national policy actors were used to: identify relevant national policies related to agriculture, development and adaptation; explore policy design and implementation processes; and discuss broad policy issues. They also identified a number of problems in implementing agricultural policies. Qualitative data from these interviews were also coded to identify reoccurring themes and generate additional insights into adaptation.

7.2.2 Policy analysis

Policy analysis was conducted to identify how issues of climate change and adaptation are handled in current national level policy documents. Past and present national level agricultural and adaptation policies were identified through a review of secondary literature and through semi-structured interviews with sub-national level decision makers. To be included in the policy analysis, policies had to be specific to the agriculture or adaptation sector and currently in operation, either strategically or in practice (Figure 7.6). Three types of policy were identified: i) adaptation policies that specifically consider adaptation to climate change, e.g. NAPA, (RoU, 2007); ii) agricultural policies that determine strategies for agricultural development, e.g. ASDSIP, (MAAIF, 2010b)); and iii) cross-cutting policies that provide an overarching policy framework and inform development priorities in across all sectors, for example, the NDP (RoU, 2010). Through this process five relevant policies were analysed. The selected five policies are highlighted in Figure 7.6 and are summarised in summarised in Table 7.3. The NAADS (NAADS, 2001), NAP (MAAIF, 2011) and ASDSIP (MAAIF, 2010b) focus specifically on the agricultural sector. The NAPA is specific to adaptation (RoU, 2007), and the NDP (RoU, 2010) provides the overall framework to guide development priorities and strategies. Iterative content analysis was used to analyse these policy documents (Forbes, 2000), which is widely for analysing textual data (Miles and Huberman, 1994). This involved examining dominant narratives within each policy document, to identify aims, objectives, activities and themes, and discover to what extent climate change was integrated into the policy.

Content analysis was further used to examine the extent to which the policy supported the four categories of agricultural adaptations. Next, overlaps and differences in the identified categories were identified, addressing similarities and differences between the analysed policy documents. Matrices were then developed to assess the results, where areas of convergence and divergence were identified. Finally, the results from the policy analysis were compared with other empirical data on autonomous adaptation.

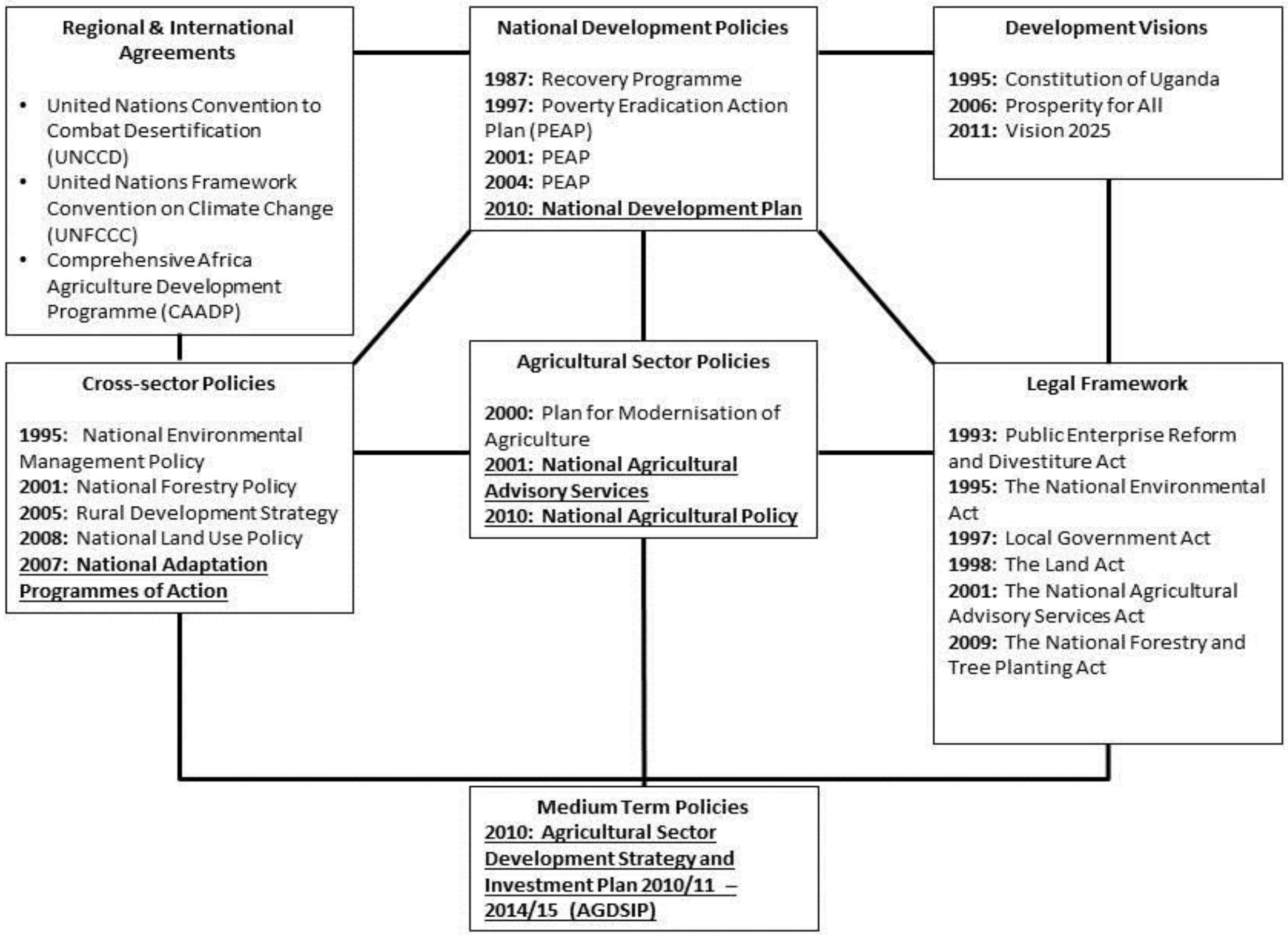


Figure 7.6 Current agriculture and adaptation policies in Uganda. Selected policies for analysis are underlined and in bold.

Table 7.3 Summary of selected policy documents

Policy	Reference	Description of document
Agricultural Sector Development Strategy and Investment Plan (ASDSIP)	MAAIF (2010b)	The ASDSIP provides detailed plans for implementation of priorities outlined in the NDP. In an attempt to prioritize investments in the sector, in 2010, the MAAIF launched a 5-year (2010/11 – 2014/15) ASDSIP. The revised ASDSIP is based on the NDP and has four programme areas of implementation that aim to promote private sector investment and raise productivity in the sector.
National Agricultural Advisory Services (NAADS)	NAADS (2001)	NAADS is a 25-year donor funded extension services and input subsidy delivery programme. The programme is now in the second phase of implementation, which started in July 2010 and ends in July 2015. The first phase was supposed to end in July 2007, but needed an extension until 2010 as NAADS II was designed. Implementation of the first phase of NAADS was tainted with challenges.
National Agricultural Policy (NAP)	MAAIF (2011)	Uganda formulated the NDP in 2010 after the expiry of the PEAP in 2008. It identifies a number of constraints that have impeded growth in the agricultural sector (primary growth sector) and proposes strategies to address these concerns. It also identifies investments to support the private sector and aims to improve access to improved agricultural technologies, improved farming practices and appropriate value addition technologies, improve financial products, and enhance linkage to markets by providing better infrastructure, especially in rural areas.
National Adaptation Programmes of Action (NAPA)	RoU (2007)	The NAPA describes the national circumstances in Uganda and identifies the potential impacts of climate change on Uganda's development. It documents urgent and immediate adaptation needs, and thus identifies priority areas for intervention. Uganda's NAPA was guided by two considerations: the need for Uganda to achieve the Millennium Development Goals (MDGs) and the country's development objectives as enshrined in PEAP (MoFPED, 2004), which has been replaced with the NDP (RoU, 2010).
National Development Plan (NDP)	RoU (2010)	The NDP covers the period 2010/2011 – 2014/15. The vision outlined in the NDP is *'a transformed Ugandan society from a peasant to a modern prosperous country within 30 years'* (p.1). The Plan aims to address structural bottlenecks in the economy in order to accelerate socioeconomic transformation for prosperity. The quasi-market approach outlined in the NDP relies on the private sector as the engine of growth and development.

7.3 Results

The first part of this section explores how farmers would use four autonomous agricultural adaptation strategies to respond to 2030s rainfall projections. The second part provides an overview of existing policies and how they consider agriculture, climate change and adaptation. The final part of the results considers the extent to which autonomous adaptation would be supported by existing agriculture and adaptation policies.

7.3.1 Practice: Autonomous adaptations to 2030s climate projections

This section provides an overview of how the four different groups of farmers identified during the analysis (Figure 7.5) would respond to 2030s' rainfall scenarios. Findings are presented and then analysed in relation to the policy analysis presented in the previous section. Table 7.4summarises the characteristics of the groups. Synthesising this information provides insight into potential autonomous agricultural adaptations and enables the identification of enabling and constraining factors for adaptation.

Overall, the Maintainers listed the smallest number of modifications to their farming practices regardless of the rainfall scenario. In Scenarios Delayed- and Timely-, farmers would make limited adjustments to their management practices. For example, they would adjust land preparation, planting and harvesting dates to respond to the onset of the rains. For Scenarios Timely+ and Delayed+, Maintainers would diversify the range of crops in order to take advantage of the rainfall conditions. Extensification through planting more land was not available to them; therefore diversification in Scenarios Timely+ and Delayed+ would also lead to intensification.

Although Maintainers were dependent on rain-fed agriculture, they were reluctant to switch crops and described how regardless of the rainfall conditions they would plant:

> *"we would do what we normally do because those are the foods that we depend on…these are our crops here, we grow them in both seasons"*

(Female Respondent, Bituli, Jinja District, 2012).

Past experiences and traditions strongly influenced what Maintainers wanted to plant. Farmers also listed a number of other barriers to further modifying their agricultural practices, including inadequate access to seeds and inputs as major constraining factors.

For the farmers with plots smaller than one acre, land was also a constraint. Alongside limited tangible inputs, strong religious beliefs prevented farmers from changing practices, as they described how God was in control of their future:

> *“there is no way you can predict these things, it is God’s will“*
>
> (Female Respondent, Bituli, Jinja District, 2012).

Table 7.4 Overview and characteristics of Groups (Maintainers, Entrepreneurs, Adapters+, Adapters-)

Name	**Location**	**Land**	**Description**	**Food / Cash Crops**
Maintainers	All farmers based in Jinja District (n=4)	Plots of less than 1 acre, unable to access other land.	• Agriculture as a main source of livelihood • Predominantly subsistence farmers, i.e. they grow mainly for home consumption,	• Food crops (maize, beans, cassava) sold if any surplus • Some cash crops planted close to the homestead (coffee) • Combination of improved (maize and groundnut) and traditional varieties (sweet potatoes).
Entrepreneurs	Includes farmers from both Jinja District and Soroti District (n=5)	Limited land for market-oriented agricultural activities (plots of less than one acre in swampy areas) Farmers able to access additional household land for plantations and food security crops.	• Other sources of income (paid employment or other agricultural activities such as cocoa, coffee and banana plantations). • Market-oriented farmers	• High value crops (tomatoes, cabbage, and aubergine). • Improved varieties and chemical inputs such as fertilisers and pesticides.

Name	**Location**	**Land**	**Description**	**Food / Cash Crops**
Adapters+	Includes farmers from both Jinja District and Soroti District (n=5)	Farmers have uncultivated land or are able to rent land.	• Agriculture is a main source of livelihood for the majority • Some households have other sources of income • Cultivate a range of food and cash crops, situated between subsistence and market-oriented production	• Crops for subsistence purposes (cassava, millet, peas, and sesame). • Some crops specifically for generating income, (certain varieties of sorghum and rice). • Surpluses of food crops (cassava) also sold • Combination of improved and traditional seed varieties
Adapters-	Predominantly from Soroti District, 1 from Jinja District (n=3)	Limited land (<2 acres)	• Agriculture is a main source of livelihood • Cultivate a range of food and cash crops, situated between subsistence and market-oriented production	• Crops for subsistence purposes (Soroti: cassava, millet, peas, and sesame; Jinja: maize, beans, groundnuts). • Some crops specifically for generating income, (certain varieties of sorghum and rice). • Surpluses of food crops (cassava) also sold • Combination of improved and traditional seed varieties

Although Maintainers would not necessarily change which crops they would plant for any of the scenarios, they would adjust the ratios of crops. As one respondent stated in response to Scenario Timely+:

> *"I won't plant as many beans as they don't do too well with too much rainfall"*

(Female Respondent, Bituli, Jinja District, 2012).

This results in a reduction in diversity and increased specialisation.

Despite the aforementioned barriers to changing management practices, the Maintainers would still find the information provided in the rainfall scenarios useful:

> *"[t]his type of information could help me plan and store some food and know what to do in the following season"*

(Female Respondent, Bituli, Jinja District, 2012).

This suggests that the Maintainers would undertake more reactive measures to cope with low yields, rather than undertaking proactive adaptation measures.

Entrepreneurs described very few modifications to their agricultural practices. In a 'normal' year, Entrepreneurs tended to make market-driven decisions, for example, based on which crops have a market and the financial resources they have to purchase inputs. This meant that Entrepreneurs would make limited adjustments to their management practices. For example, they would adjust the timing and application of fertilisers and pesticides rather than switching crops. In Scenarios Delayed- and Timely-, Entrepreneurs would cultivate less land by changing the ratio of crops to land, resulting in extensification. One of the farmers would also reduce the range of crops and plant only drought resistant varieties, resulting in specialisation. The other farmers in this group would not change crops while there is a market demand for them. They would only respond to rainfall scenarios if they thought they would incur financial losses by not doing so.

Table 7.5 Examples of agricultural adaptations used under the 4 rainfall scenarios

	Examples of agricultural adaptations	**Maintainers**	**Entrepreneurs**	**Adapters+**	**Adapters-**
Intensification	Increase crop to land ratio Reduce the amount of land cultivated	Timely+, Delayed+	Timely+, Delayed+	Delayed-, Timely-	Timely+, Delayed+
Extensification	Reduce the crop to land ratio Increase the amount of land cultivated	NOT USED	Delayed-, Timely-	Timely+, Delayed+	Delayed-, Timely-
Diversification	Increase the range of cultivated crops/varieties Adjust the ratios of cultivated crops	Timely+, Delayed+	NOT USED	Timely+, Delayed+	Delayed-, Timely-
Specialisation	Reduce the range of cultivated crops/varieties Adjust the ratios of cultivated crops	Delayed-, Timely-	Delayed-, Timely-	Delayed-, Timely-	Timely+, Delayed+
Other Adjustments	Change planting dates Crop Rotation Switch crops	Limited	Limited	All	All

For Scenarios Timely+ and Delayed+, Entrepreneurs would use their usual intensive practices and increase the ratio of crops to land and pesticide use, but make no changes to the range of crops under cultivation; this would result in intensification at the farm-level. Farmers' decisions about the crop to land ratio predominantly depended on household financial resources available to buy seeds, other chemical inputs and labour to implement the intensive practices. These results demonstrate that market demands and financial resources were more important drivers of decision-making for Entrepreneurs than rainfall conditions.

In a normal year, Adapters+ have uncultivated land. They predominantly adjusted the amount of land they would cultivate in response to the various rainfall scenarios. For scenarios Delayed- and Timely-, farmers would reduce the amount of cultivated land and adjust the range of crops, leading to intensification. Farmers would increase the amount of cultivated land in Scenarios Timely+ and Delayed+ and similarly adjust the range of crops. However, the specific ways in which farmers would adjust their crops varied across the four rainfall scenarios. Some would take the same action for all scenarios, whereas others would specialise or diversify depending on the rainfall scenario. This highlights that a diverse range of responses would be undertaken at the farm-level by the Adapters+. Selection of particular crops and the range of crops depended on factors including the management requirements of the crop and the availability of labour. Labour was the biggest constraining factor amongst the Adapters+.

In a normal year, Adapters- tend to cultivate all of their land as they depend on the output from it. Similar to the Adapters+, the details of farm-level agricultural adaptations amongst Adapters- varied between households. However, adaptation options of Adapters- are limited by access to land. Some farmers would try to rent land if they were expecting a 'good year' or had a previous good year to take advantage of potential opportunities. However, this depended on other household preferences, priorities and needs, labour, and access to other agricultural inputs. For Scenarios Delayed- and Timely- Adapters- would practice extensification, i.e. they would cultivate a smaller land area or reduce the crop to land ratio. In addition, farmers would switch between crops resulting in either specialisation or diversification depending on the range of crops cultivated. The level of diversification or specialisation varied across this group. Similar variations were observed in farmer responses to Scenarios Timely+ and Delayed+, where no particular pattern emerged in the extent to which farmers would diversify or specialise. However, farmers would increase the crop to land ratio and therefore both diversification and specialisation would result in intensification under Scenarios Timely+ and Delayed+.

Farmers draw upon adaptation strategies according to a range of local level factors, for example: the nature of the production system, the range of non-agricultural livelihood activities, access to land and the availability of the human resources (labour) and financial resources to purchase inputs, land, labour and meet other household needs. Findings suggest that health and well-being of the farm household are important in shaping both labour availability and the surplus of financial resources available to invest in agriculture:

> *"When you are sick even if it is raining then you can't go to the garden, so that one is affecting us….. Even though you have the inputs, when you are sick there is nothing you can do."*

(Female Participant, Kalugu, Jinja District, 2012).

> *"when sickness comes at home you find yourself also in very big problems. The money is less, so you find you don't have money, you don't have any to spare for home needs, seeds, thing like that. It makes life difficult and complicated."*

(Male Respondent, Bukolokoti, Jinja District, 2012).

Low yields, resulting in low income, influences food and income availability at the household level. At the same time other household needs such as healthcare and paying school fees also constrain the availability of financial resources within the farm household:

> *"If yields are always low, then you can only sell little and then you don't have money to pay for school fees".*

(Female Respondent, Bituli, Jinja District, 2012).

> *"from that little money we get…… I pay school fees from there. I can use it for home consumption, home needs and problems, such as buying paraffin. If you fall sick, you also need money to get to the clinic."*

(Male Respondent, Kalugu, Jinja District, 2012).

> *"the problems people really face are sickness and famine, how to feed is a problem. When you use that money there on health, you will not have any money left to feed or eat at home…. human sicknesses really removes cash from the hand."*

(Female Participant, Kangeta, Soroti District, 2012)

Farmers described how social networks could be drawn upon in the absence of labour, seeds, land, food and financial resources to provide food and/or financial support. Social networks are a traditional means for exchanging labour for seeds, food and money, though this is declining in Jinja District. This decline in traditional practices is supported by results presented in Chapter 5.

> *"it is a culture here in Teso, for you, you have been affected by the flood, but you as another person have food, so you will have to go and offer your labour to that household, then you are given food in return for your labour."*

(Female Participant, Kangeta, Soroti District, 2012).

> *"People used to have seeds. Even if you asked from your neighbour, they could give you seeds…today it is not the same, even from your neighbour you have to buy."*

(Female Respondent, Kalugu, Jinja District, 2012).

In Jinja District, farmers identified paid employment and buying and selling food as alternative strategies, if autonomous agricultural adaptations were limited (cf. Chapter 6). These findings demonstrate that household-level adaptation options are influenced by interactions between natural resources (land, seeds), human resources (health, labour), social networks and financial resources (to obtain inputs, hire labour, rent land). Access to and availability of such resources influences, and is influenced by, past decisions and the current decision-making context.

7.3.1.1 Decision-making

Analysis of decision-making throughout the season demonstrated that agricultural adaptations are influenced by a range of factors operating at different levels (cf. Chapter 5). For example, at the individual level farmers have their own priorities and preferences about what crops they want to cultivate. These priorities and preferences can also change over time, including during a growing season, and are influenced by a range of climatic and non-climatic factors, which will be explored in this section (Table 7.6).

Table 7.6 Overview of the climate and non-climate factors that influence decision making and agricultural adaptations. Climate factors are highlighted in bold.

Decisions stages	**Factors affecting farmer decisions**
Preparations	• **Length of dry season** • **Onset of first rains** • Labour availability • Health status of household • Land availability

Planting	• **Onset of first rains**
	• Past experience 'normal climate'
	• Market prices
	   • Seed and labour availability
	   • Household needs
	   • Knowledge

Management practices	• **Amount of rainfall received**
	• **Average temperatures**
	• Access to inputs
	   • Labour availability
	   • Which crops were planted
	   • Presence of pests and diseases

Harvesting	• **Temperatures/cessation of rainfall –** ability to dry crops • Availability of other food / crops
Post harvest	• Actual yields • Market access & prices • Space availability to store crops • Use of granary (traditional practice) • Household needs (e.g. school fees, healthcare)

Decisions about when to prepare the land are influenced by the expected onset of the rains and the length of the previous dry season. For example, if the dry season has been long, then the ground may be hard, and farmers will try to prepare early. In Soroti District, the timing of land preparation can also depend on a household's access to oxen and an ox-plough.

Planting decisions are influenced by a range of climate factors, including experiences of past climates and expected rainfall. In Jinja District, farmers use months to guide their expectations, for example, farmers expect rains in March, so prepare land and organise inputs (labour, seeds etc.) accordingly. In some cases weather forecasts provided by local radio were also used in particular months to guide such decisions. In Soroti District, there is evidence that farmers use weather forecasts in conjunction with some local indicators such as the direction of the winds, certain bird and trees species. Decisions about which crops to plant are also shaped by a range of human factors, including: market prices, access to seeds, and labour availability, as highlighted in Case Study 6 (Box 8).

Planting decisions in the second season also depend on the outcome of the first season, which influences availability and access to seeds, other inputs and labour. Additionally, in Jinja District, it is common that the same plots of land are cultivated in both seasons, due there being small and limited availability of additional land. This means that the timing of the first rains, and duration of the first season have implications for second season decisions, and therefore the outcomes of the second season.

Management practices depend on the crops that have been planted, the amount of rainfall that has been received and the average temperatures. For example, if heavy rainfall is experienced then crops such as groundnuts may need additional weeding. Additionally, management practices depend on a farmer's ability to access inputs (fertilisers, pesticides), and labour availability or ability to hire labour to apply inputs or carry out weeding activities. There was evidence that these factors also influenced planting decisions, demonstrating the importance of resource access at the household level in shaping agricultural adaptations throughout the growing season.

Decisions about when to harvest and what to do with the harvest are predominantly influenced by non-climatic factors. Case Study 6 (Box 8) compiled a from semi-structured interview with a farmer in Phase II provides an example of how non-climatic factors operating at a local level can shape priorities, preferences and ultimately household decisions. Temperature and the cessation of rainfall influence decisions about when to harvest, and in some cases influenced farmer decisions on whether or not to sell or store crops. However, in Jinja District these decisions were significantly influenced by market prices and household needs to buy food and pay school fees. In Soroti District, farmers were more cautious about selling crops unless they were specifically grown to generate income. In such cases, farmers still demonstrated an overall preference for storing crops, unless money was needed to fulfil household needs.

Differences between farmers in terms of access to resources and the combinations of autonomous agricultural adaptations demonstrate that farmers are following different strategies, resulting in multiple adaptation pathways. Adapters+ and Adapters- pursue a more diverse range of strategies when compared with Maintainers and Entrepreneurs. Maintainers and Entrepreneurs consistently draw upon intensification and specialisation, whereas Adapters+ and Adapters- demonstrate a more diverse range of agricultural adaptations. The following section unpacks which autonomous agricultural adaptations, and therefore which farmers, are supported by current agriculture and adaptation policies. This is important because it enables the identification of winners and losers, highlighting important considerations for equity, justice and fairness of planned and autonomous adaptation (Leichenko and O'Brien, 2006).

Box 8, Case Study 6, Christine, Adapter+, Soroti District

Christine supports her family of 4 on a plot of land around the size of an acre. Christine doesn't usually sell much of what she produces, *"most of the food that is produced stays at home for feeding".*

In the first season, if the rains come in time, she normally grows a mix of crops, including cassava, sorghum, sweet potatoes, millet and groundnuts. If the rains are delayed or she is expecting low rainfall, then she will reduce the variety of crops she grows and focus on cassava and sorghum. If she is expecting increases in rainfall, then she will try and rent some land from a friend or family member, so that she can grow some surplus crops. If she doesn't have money, the she can rent land in arrears, which she will pay at the end of the season, or she offers her labour in exchange for a plot of land.

As the head of the household, Christine depends on herself and her children to provide labour for cultivation. Last year she fell sick, and was only able to cultivate a small portion of her garden. This has had knock on effects for this season. For example, Christine does not have enough seeds to plant. She also hasn't saved enough money to send her children back to school. To generate income, she has worked in her neighbour's garden to provide casual labour. This means that even though the rains have returned on time, she has delayed planting her own crops and is not expecting to have a good yield this season.

Christine's story demonstrates how non-climatic factors operating at a local level can shape priorities, preferences and ultimately household decisions.

7.3.2 Policy: Overview of current agriculture and adaptation policy

Table 7.7 provides a summary of the national level policies relevant to agricultural adaptation including a brief description of how agriculture, climate change and adaptation are treated. All of the policies reviewed identify agriculture as an important sector in terms of economic growth, development and poverty eradication. At the same time, the agricultural policies identify a number of constraints that have impeded productivity, for example low soil fertility, poor management practices evidenced by low rates of fertiliser usage, and inadequate access to markets. Climate changes are also identified as factors that have limited productivity and as future risks. However, the NAPA (RoU, 2007) is the only relevant policy that focuses explicitly on climate change and adaptation and the impacts across other sectors, such as water and health. In the agricultural policies reviewed, both climate change and adaptation are considered, though to varying degrees.

Table 7.7 Overview of selected agriculture and adaptation policies.

	Description	**Agriculture**	**Climate change**	**Planned adaptations**
National Development Plan 2010/11 - 2014/15 **(NDP)** **(RoU, 2010)**	The NDP for Uganda outlines strategic direction, development priorities and implementation strategies to achieve them. It aims to accelerate socioeconomic transformation for prosperity and bring a third of the population out of poverty.	• This policy recognises that agriculture is a primary growth sector. This policy identifies a number of constraints that have impeded growth in the agricultural sector. It also outlines strategies to address such constraints.	This policy: • recognises that climate change is an enabling factor for economic growth and development. • recognises that weak management of environment and climate change are problematic. • includes limited consideration of adaptation to climate change. • has a specific objective to address the legal and institutional frameworks necessary for the implementation of the UNFCCC.	This policy: • recognises mainstreaming in the development of policies, strategies, programmes and projects • includes strategy to build capacity to respond to climate change. For example: • Allocate more resources to increase the accessibility to water for production • Total overhaul and automation of the meteorological services

	Description	Agriculture	Climate change	Planned adaptations
Agricultural Sector Development Strategy and Investment Plan 2010/11 - 2014/15 **(ASDSIP)** **(MAAIF, 2010b)**	The ASDSIP addresses the weaknesses of earlier policies and provides detailed plans for implementation of priorities outlined in the NDP. The policy aims to raise rural household incomes and improve the food and nutrition security of all Ugandans.	• The DSIP focuses on four broad and mutually reinforcing investment programmes: enhancing agricultural production and productivity; improving access to and sustainability of agricultural markets; creating an enabling environment for investment in agriculture; and strengthening agricultural institutions	This policy recognises that: • climate change is a cross cutting issue. • climate change has negative consequences for production, e.g. potential negative climate impacts on coffee, with negative implications for economy.	• This policy proposes strategies such as sustainable land and water management and building capacity for climate change adaptation.

	Description	Agriculture	Climate change	Planned adaptations
National Agricultural Policy **(NAP)** **(MAAIF, 2011)**	This policy guides all agriculture and agriculture related subsector policies, policy frameworks and strategies existing or to be formulated in future.	• This policy provides guidance to all actors in the agricultural sector to make investments that will increase agricultural incomes, reduce poverty, improve household food and nutrition security, create employment and stimulate overall economic growth.	This policy: • recognises that climate change is an emerging threat. • recognises that climate change has not received as much attention as it should at policy and implementation levels.	This policy: • Does not explicitly consider adaptation. • Proposes interventions to develop capacity for planning and budgeting processes at all levels to address climate change and its impact on agriculture.

	Description	**Agriculture**	**Climate change**	**Planned adaptations**
National Adaptation Programmes of Actions (NAPA) **(RoU, 2007)**	The NAPA identities potential climate impacts in Uganda, and outlines priority areas for investment and future support. Participatory methods were used to elicit the views of vulnerable communities and their knowledge on coping mechanisms.	• This policy recognises the major factors that influence agricultural production include soils, climate, agricultural implements, management practices and access to markets (both domestic and international).	This policy recognises that: • climate change will affect every sector of development, and potentially undermine efforts to reduce poverty and the achievement of the millennium development goals. • agricultural performance fluctuates with climate change and variability, and is also adversely affected by means of production, poor markets and storage facilities.	• Agricultural adaptations are presented in the NAPA, e.g. Water for Production Project, alongside a set of broader planned adaptation interventions.

	Description	Agriculture	Climate change	Planned adaptations
National Agricultural Advisory Services (NAADS) **(NAADS, 2014, NAADS, 2001)**	NAADS is a 25-year donor funded extension services and input subsidy delivery programme. The programme is now in the second phase of implementation, which started in July 2010 and ends in July 2015. NAADS is one of the seven components under the Plan for Modernization of Agriculture (PMA), the planning framework of the government for the transformation of subsistence agriculture to market-oriented agriculture for commercial production.	NAADS comprises 5 components: 1: Advisory and Information Services to Farmers 2: Technology Development and Linkages with Markets 3: Quality Assurance - Regulation and Technical Auditing of Service Providers 4: Private Sector Institutional Development 5: Programme Management and Monitoring and Evaluation	• Climate change not explicitly considered.	• Climate change adaptation not explicitly considered. • Adaptation is considered as technology adoption.

In the NAPA, agriculture is identified as a vulnerable sector to climate change (RoU, 2007), and adaptations relevant for the agricultural sector are presented alongside a set of broader planned adaptation interventions that cut across multiple sectors (RoU, 2007). Although the NAPA proposes specific agricultural adaptation interventions, for example 'Water for Production', agriculture also features as a component of other projects, for example the 'Land Degradation Management Project' and the 'Vectors, Pests and Disease Control Project' (RoU, 2007). Analysis of how each of these interventions are ranked according to priority in the NAPA highlights some similarities and differences between the priorities of local communities and national development objectives (RoU, 2007). For example, in the NAPA, water resources and on-farm forestry emerge as high priority interventions by multiple stakeholder groups, including local communities (RoU, 2007). However, there are also some differences. For example, indigenous knowledge, which ranked first by communities, is ranked seventh in the final list of priority interventions once other stakeholder perspectives, national development objectives and the NAPA are taken into account (RoU, 2007). This demonstrates that there are differences between policy priorities and priorities of other stakeholders (including local communities).

The NDP gives limited consideration to adaptation to climate change. However the policy does propose some interventions to encourage planned adaptation, for example the mainstreaming of adaptation in the development of policies, strategies and programmes across sectors (RoU, 2010). The NDP highlights some general planned adaptation interventions, for example, the need to build capacity to respond to climate change and to address the legal and institutional frameworks necessary to implement the NAPA (RoU, 2010). The NDP also proposes some interventions specific to the agricultural sector, for example, the need to allocate more resources to increase the accessibility of water for production (RoU, 2010).

Both the NAP and ASDSIP recognise climate change as an emerging threat to agricultural production (MAAIF, 2010b, MAAIF, 2011). The NAP states that "*climate change has not received as much attention as it should at policy and implementation levels*" (MAAIF, 2011:21). However, adaptation to climate change is not specifically considered by the NAP or in detail by the ASDSIP (MAAIF, 2010b, MAAIF, 2011). Instead, the policies propose general adaptation interventions to reduce the impact of climate change on agriculture, such as capacity development for planning and budgeting processes at all levels and the and the promotion of sustainable land and water management (MAAIF, 2010b, MAAIF, 2011).

NAADS, although a central government policy, is delivered through the decentralised local government system. Neither climate change nor adaptation is considered in the original NAADS programme implementation manual (NAADS, 2001). Findings from interviews with farmers and sub-national NAADS officials confirmed that the priority for NAADS in practice has been to provide input subsidies and extension services. Although in principle the services are designed to be responsive to farmer needs, the overall goal is the commercialisation and modernisation of agriculture (NAADS, 2001):

> *"as much as we are trying to move from subsistence to commercial farming we have some constraints, and it's leaving some farmers behind".*

(Soroti District, Agricultural Extension Officer, Interview, July 2012)

> *"In my department, as far as agriculture is concerned, we conduct trainings. We make demonstrations of modern practices so that the community can look at theirs [farms] and what is happening on our demonstration…We even drive farmers in groups to see commercial farms, because once they are in a group they can change"*

(Jinja District, Agricultural Extension Officer, Interview, June 2012)

Commercialisation and modernisation both underpin extension services, the inputs that farmers can access through NAADS (NAADS, 2001), and reflect the vision set out in the NDP (RoU, 2010). Sub-national district officials are responsible for implementing the priorities and interventions proposed in agricultural policies. Sub-national district officials confirm that the focus of agricultural extension is on providing improved technologies and encouraging mechanisation, specialisation and commercialisation as a way to increase production.

> *"We promote commercial crops and modern agricultural practices, but they are expensive to poor farmers. Some farmers cannot afford a tractor, it's expensive, so the common person in the village [thinks that] maybe the modern technologies are too expensive and that they cannot afford it"*

(Soroti District, Agricultural Extension Officer, Interview, June 2012)

These policies are in line with Uganda's national level development priorities and objectives:

> *"The policies do exist, and they focus on agricultural production, which in turn relies on what the government thinks. This has become a problem because people come up with these policies, but they may not be the best ones".*

(Jinja District, Agricultural Extension Officer, Interview, July 2012)

7.3.3 Comparing policy and practice: Who is policy supporting?

None of the policies explicitly promote autonomous agricultural adaptations as strategies to deal with climate change. However, all of the reviewed policies consider one or more of the strategies that farmers may use. A summary of the findings is presented in Table 7.8.

All farmers reported using intensification as a response to future rainfall scenarios. Maintainers, Entrepreneurs and Adapters- would all use intensification to take advantage of opportunities presented by increased rainfall totals, regardless of the onset of the season. However, Adapters+ used intensification when delayed rains and lower rainfall totals were expected. At the same time, all of the reviewed policies support intensification as a means to enhance agricultural production, evidenced by the support for labour saving technologies, high yielding species, breeds and varieties across the various policy documents. Intensification is mentioned alongside agricultural commercialisation, mechanisation and modernisation, demonstrating clear links between the reviewed policies, Uganda's development objectives, and autonomous agricultural adaptations.

Adapters+ would use extensification to respond to expected increases in rainfall. However, in response to decreasing rainfall, Entrepreneurs and Adapters- would use extensification to reduce inputs, labour and resources. Maintainers would not use extensification. The NAPA and NAADS do not explicitly consider extensification. Both the NAP and the NDP recognise that through the use of technology, more land can be brought under cultivation to increase production. The ASDSIP proposes increasing acreage of land for livestock, rather than crop production specifically. The ASDSIP also notes that population pressures are reducing opportunities for opening up new land and therefore intensification is needed to increase future production and productivity (MAAIF, 2010b). However, limited policy support is given to extensification highlighting that as population densities increase and land fragmentation takes place, farmers may be forced to shift from extensive to increasingly intensive production systems. This potentially undermines the potential of policy to support Adapters+ to take advantage of opportunities associated with increased rainfall.

Maintainers, Adapters+ and Adapters- would all use on-farm diversification in different ways. For example Adapters- would combine diversification with extensification to respond to decreases in rainfall. However, Adapters+ would use the same strategies to respond to increases in rainfall. Yet, there is limited consensus across the policies on support for agricultural diversification (Table 7.8).

Diversification of diets, markets, financing support and livelihoods is promoted as a means to ensure food and nutrition security by the NDP, NAP and ASDSIP. The ASDSIP also recognises that diversification is a means to scale up sustainable land management. Economic diversification is recognised by the NDP as a desirable goal at the national level, by diversifying into other sectors, e.g. oil, and diversifying the range of agricultural products Uganda produces. Diversification is also recognised as a national level goal and a means to promote food and nutrition security at the household level. However, on-farm diversification is not supported by current policy as a management strategy at the farm-level.

Diversification at the national level is being achieved by promoting on-farm specialisation, but this is reducing the autonomous agricultural adaptation options available to farmers. National level development objectives of specialisation and strategic enterprise selection are being implemented at the local level and undermining the ability of households to implement on-farm diversification. This demonstrates that there are areas of divergence between current policy priorities and autonomous adaptation actions undertaken by farmers.

The lack of support for diversification at the sub-national level (including the farm-level) can be contrasted with the consistent support across policies for intensification and specialisation. One of the NAADS principles is *"increased commercialisation-including intensification of productivity and specialisation*" (NAADS, 2001:9). The NAP, NDP, and ASDSIP promote strategic enterprise selection at the sub-national level. The focus of strategic enterprises is in accordance with the 10 Agricultural Production Zones (APZs), which were identified by the MAAIF in 2004 (RoU, 2004). Agro-zoning not only promotes specialisation, but also promotes large scale farming enterprises, including plantations and estates (RoU, 2004). This demonstrates that agricultural policies in Uganda specifically support specialisation, intensification and commercialisation simultaneously.

Specialisation is not always used by farmers in conjunction with intensification, although these two ideas are linked in current agricultural policy (MAAIF, 2010b, MAAIF, 2011, NAADS, 2001). Although findings confirm that farmers would use both intensification and specialisation, they also highlight that farmers would use these adaptations in different ways and in conjunction with other adaptations. Adapters+ would use specialisation and intensification under scenarios of lower rainfall and shorter growing seasons (Delayed-), whereas Adapters- would do the opposite. Adapters- would use specialisation, in combination with intensification, to take advantage of rainfall increases. Other farmers

(Maintainers, Entrepreneurs) would also use specialisation to respond to expected decreases in rainfall. These differences in how farmers use intensification and specialisation highlight an important area of divergence between autonomous agricultural adaptations and policy driven adaptation.

Farmers would use a combination of extensification, intensification, diversification and specialisation strategies in response to 2030s' rainfall scenarios. However, under certain rainfall scenarios, policies would not support the range of autonomous agricultural adaptations used by farmers. For example, under rainfall scenarios Delayed- and Timely-, current policy would converge with the intensification and specialisation strategies of the Adapters+, and would support the specialisation strategies of Maintainers and Entrepreneurs. However, current policy would diverge with the autonomous adaptations of the Adapters-, who would use diversification and extensification under such rainfall conditions, and who would therefore receive little policy support. This example demonstrates that current policies and future rainfall changes could create winners and losers.

Table 7.8 Comparison between farmers' autonomous agricultural adaptations to 2030s' rainfall and the adaptations supported by current policy.

Agricultural Adaptation	Maintainers	Entrepreneurs	Adapters+	Adapters-	NDP	NAP	ASDSIP	NAADS	NAPA
Intensification	Timely+, Delayed+	Timely+, Delayed+	Delayed-, Timely-	Timely+, Delayed+	X	X	X	X	X
Extensification	NOT USED	Delayed-, Timely-	Timely+, Delayed+	Delayed-, Timely-	X	X	X	NOT MENTIONED	NOT MENTIONED
Diversification	Timely+, Delayed+	NOT USED	Timely+, Delayed+	Delayed-, Timely-	NOT MENTIONED	X	X	NOT MENTIONED	NOT MENTIONED
Specialisation	Delayed-, Timely-	Delayed-, Timely-*	Delayed-, Timely-	Timely+, Delayed+	X	X	X	X	NOT MENTIONED

*Also influenced by market opportunities
X = mentioned in the policy

The major areas of divergence between policy support and autonomous adaptation is found in the limited support provided for extensification and diversification. This highlights that extensification and diversification are not consistently supported by agricultural or adaptation policy in Uganda. Yet, these adaptation strategies would be used by farmers to adapt to 2030s’ rainfall scenarios. Autonomous adaptations of extensification and diversification undertaken by the Adapters+ and under Timely- scenario would be unsupported by current policy. Instead, policy supports intensification and specialisation, which supports other farmers. Additionally, intensification and specialisation strategies would help Adapters- to take advantage of opportunities presented by increases in seasonal rainfall (Timely +) and enable Adapters+ to minimise the risks presented by reduced rainfall and shorter growing seasons (Delayed-).

7.4 Discussion

Importantly, this chapter reveals that farmers would use autonomous agricultural adaptations to respond to rainfall scenarios in different ways (Table 7.8). The first part of this section explores some of the differences that emerged between farmers’ autonomous agricultural adaptations, and through this identifies some enabling and constraining factors. The second part highlights some of the findings from the policy analysis and discusses the implications of the areas of divergence and convergence that were revealed. The final part explores which autonomous agricultural adaptations are supported by current policy and discusses some of the implications in terms of future adaptation research, policy and practice.

This chapter identified a number of differences between the types of autonomous agricultural adaptations smallholder farmers would draw upon in response to potential 2030s’ rainfall scenarios. Overall, findings demonstrate that farmers would adjust their agricultural practices in response to 2030s’ rainfall scenarios. These findings confirm the importance of rainfall in influencing growing seasons in Uganda (Riddle and Cook, 2008).

Similarities and differences both between and within study districts were identified. This confirms that individual farm households with broadly similar resource bases and enterprise patterns can be grouped together within a geographical space, in this case within an administrative district (Dixon et al., 2001). For example, for the farmers in Groups 1 and 2, predominantly from Jinja District, market access, a formal institution, emerged as an important factor that enabled households respond when other resources were limited. Amongst Adapters+ and Adapters- in Soroti District, social networks provided such additional support. This demonstrates that formal and informal institutions play different roles in supporting autonomous adaptation at the household level, depending on the system of farming. To better support farmers in Jinja District, support is needed to enhance formal institutions, and strengthen informal institutions such as social networks (Berman et al., 2012). Indeed, other studies show that policy appears to inadequately support adaptations that rely on such informal networks (Stringer et al., 2009). This suggests that future adaptation support could be better targeted, designed, and implemented, at the district level to build inclusive institutions, i.e. through a participatory and decentralised governance system. This could result in adaptation support that better reflects the diversity of farming systems in Uganda.

Findings presented in this Chapter also demonstrate that farmers within the study districts would adapt their practices to the same rainfall scenarios in different ways, highlighting the importance of non-climatic factors in shaping agricultural adaptations. Such human factors are influenced by the social, economic, biophysical context, which then shape how farmers respond to pressures and opportunities. In practice, this interconnectedness between context and decisions makes it difficult to distinguish between autonomous and planned adaptations. This chapter provides evidence to suggest that contextual factors shape decision-making at different levels, and as such, should be included in the FSAC framework (Figure 2.2). Pressures and opportunities, including climate hazards, are part of the wider social, economic, institutional and biophysical context, which also sets the boundaries of the FSAC framework (Figure 7.7). Recognising that all components, of the FSAC framework, including decision-making, are embedded within a wider context offers an important contribution to advancing understanding of connections between components of the FSAC framework; this is reflected in the advanced FSAC framework (Figure 7.7).

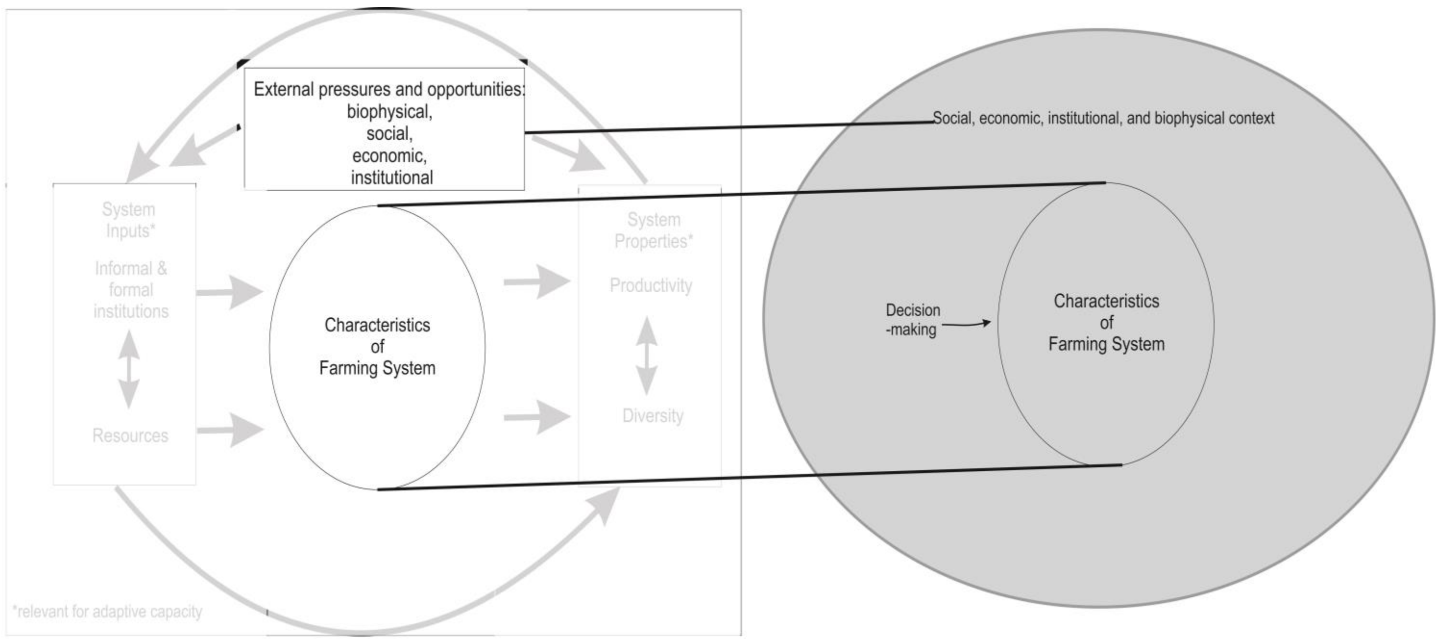


Figure 7.7 Illustration of the how Chapter 7 findings advance the Farming System Adaptive Capacity framework (Figure 2.2). Modifications are highlighted in grey to demonstrate the link between decision-making and the characteristics of farming system, and how external pressures and opportunities are part of the wider social, economic, institutional context.

Differences between households within the study districts can be explained by variations in access to resources at a household level, for example differences in land and labour. The influence of household-level resource access in shaping adaptation is consistent with other studies that highlight the importance of land (Simelton et al., 2009, Fraser and Stringer, 2009). Resource access combined with the priorities and preferences of farm households determine the system of farming at the farm level. However, other studies and earlier chapters in this thesis highlight that resource access and utilisation are influenced by factors operating across multiple scales (Antwi-Agyei et al., 2014, Osbahr et al., 2008a, Thomas et al., 2007). As Darnhofer et al. (2012) note, three sets of interacting factors need to be taken into account: the farmer (family, projects, perceptions, preferences and history); the farm with its resources; and the biophysical, social, economic and institutional context. These factors interact to situate the goal of the production system along a continuum of subsistence to market oriented (Morton, 2007). This demonstrates that farm households within the same farming system have different 'systems of farming' (Sumberg et al., 2013, Giller, 2013). This implies that effective policy should recognize that in the same way there is no 'one-size-fits-all' technology, there is no 'one-size-fits-all' policy (Giller, 2013).

At the same time, the grouping of farmers according to similarities in responses to future rainfall projections demonstrates that within a farming system, similarities can be identified between individual farm systems and systems of farming. Such similarities suggest that within a farming system, individual farm systems can be clustered according to similarities in systems of farming, for example, farmers with more land and labour have a greater range of adaptation options. Access to land and labour are shaped by a range of institutional factors, and emphasise the importance of institutional context in shaping agricultural adaptations (Brugger and Crimmins, 2013, Stringer et al., 2010), thus highlighting an area for continued efforts to explore the institutional dimensions of adaptation.

Grouping farmers in this study demonstrated that farmers would use different strategies to respond to 2030s' rainfall projections and are therefore likely to follow contrasting adaptation pathways (Zorom et al., 2013). Multiple adaptation pathways are not supported by current agricultural or adaptation policy in Uganda. Furthermore, some autonomous agricultural adaptations are excluded from policy support. For example, intensification and specialisation receive consistent policy support, yet diversification and extensification are not supported by policy. In particular, the creation of APZs as a means to diversify the national economy has resulted in specialisation at the sub-national level. This is important for four reasons which will now be explored.

Firstly, intensification and specialisation strategies can act to reduce response options and diversity at the household-level. This risks lock-ins to particular inflexible farming systems and development trajectories, which may undermine the capacity of households to adapt to future climatic and non-climatic changes (Wilson, 2013). It also has the potential to create winners and losers, and therefore has social justice implications (Adger et al., 2006, Schneider and Lane, 2006). For example, in this study the majority of farmers in Soroti District would use on-farm diversification under certain rainfall scenarios; however this is not supported by current policy. Adaptation strategies of intensification and specialisation undertaken by market-oriented and subsistence farmers in Jinja District are supported by policy, but this is having varying impacts on availability of food at the household level, as demonstrated by the increase in food shortages reported by farmers in Jinja District (Chapter 5).

Secondly, intensification and specialisation are known to have wider negative environmental impacts (Carswell, 1997, Cortez-Arriola et al., 2014, Stoop et al., 2002), yet these are not recognised by current policies. Sustainable intensification has emerged to try and address some of these negative impacts (Stoop et al., 2002). However, the ASDSIP is the only policy which considers the notion of sustainable intensification (MAAIF, 2010b), i.e. increasing the productivity of land and genetic resources in ways that do not compromise the quality and future productive capacity of those resources (FAO, 2005a). However, the ASDSIP fails to define or provide guidance about sustainable intensification. Furthermore, sub-national officials in both study districts did not have clear guidelines on what sustainable intensification is or how to implement it.

Thirdly, policy interventions in Uganda’s NAPA are designed in accordance with Uganda’s development priorities, and support agricultural modernisation and intensification including the use of high yielding species, varieties and breeds (RoU, 2007). However, this can reduce farming system adaptive capacity (Chapter 5) and shift vulnerability to market-based institutions (Chapter 6). This raises important questions about how policies interact to have impacts across different spatial scales (Twyman et al., 2011) and who is benefiting from existing policies and who is being marginalized (Stringer et al., 2010). This highlights the broader need for research to unpack the extent to which the national development priorities and objectives will lead to benefits at the household level. Further studies are required to understand who is benefitting from current agricultural policies in Uganda, who is being marginalized and why (Friis-Hansen et al., 2004).

Finally, evidence in this study suggests that intensification and specialisation may not have the desired impact on poverty reduction or development at the local level, including at the household level. The inflexibility of the systems of farming meant that farmers would be unable to respond to changes in rainfall. The inflexibility was influenced by dependence on market-oriented agriculture in the case of the market oriented farmers, and by limited knowledge and access to resources amongst subsistence households. Given the uncertainties surrounding future climate change and variability, this inflexibility is potentially problematic. Resources are needed to foster a range of response options, which requires institutions that support flexibility and diversity (Fazey et al., 2009). These empirically grounded findings advance understanding of the links between system properties and future access to and utilisation of system inputs, which can contribute to broader debates surrounding feedbacks and the temporal dynamics of the nature of farming system adaptive capacity. Advancing the FSAC framework further, requires consideration of the feedbacks between system properties and inputs.

In summary, farm households use a range and combination of strategies, depending on rainfall scenarios, making it difficult to isolate consistent autonomous adaptation patterns at a local level (Thomas et al., 2007).Different climate factors emerge as being important throughout a growing season. This has important implications for the provision of weather information to support the agricultural sector and the types of climate services farmers need (for example see Patt and Gwata 2002). In addition to this, a range of non-climatic factors influence farmer decision-making, which demonstrates the importance of considering the wider context in which decisions are situated. Local level factors, including household-level decision-making processes, are often overlooked in studies of agricultural adaptation, and are thus an area requiring additional research. These findings highlight what Wilby and Dessai (2010) refer to as the expanding envelope of uncertainty of adaptation responses, where a cascade of uncertainties proceeds from different socio-economic and demographic pathways, to the adaptation options and the subsequent impacts on human and natural systems. However, this chapter has demonstrated that current polices in Uganda do not support multiple response options or adaptation trajectories. Keeping options open is vital in dealing with uncertainties surrounding future climate change and variability (Herrero et al., 2014). This is not the case in Uganda, where national policies support intensification and specialisation, thus undermining extensification and diversification efforts.

7.5 Summary of Chapter 7

This chapter has integrated climate science, policy and practice to provide additional insight into how farmers may adapt to 2030s' rainfall projections and where further work and additional support may be needed.

Findings suggest that farmers would adapt their systems of farming in different ways depending on rainfall scenarios, both in the number and the nature of autonomous agricultural adaptations. Multiple trajectories of agricultural adaptations exist, thus, farm households face different issues in terms of what resources are needed. However, similarities were also identified between how farmers would adapt, leading to the grouping of farmers, which could be used to better target adaptation support. Understanding the similarities between farm households within groups confirmed the importance of considering resource access (specifically land, labour and agricultural inputs) and the goal of the farming system (i.e. where it is situated on a continuum of subsistence and market oriented agriculture), in shaping the ability of farm households to adapt their agricultural practices.

Current agricultural policy in Uganda does not support the diverse range of autonomous agricultural adaptations. For example, specialisation and intensification are consistently supported, whereas diversification at the farm-level is not. This means that some responses, and therefore some farmers, are being marginalised. Furthermore, in practice, intensification and specialisation may not have the desired impact on poverty reduction or development at the household level, highlighting trade-offs between short-term productivity and long term adaptive capacity. There is a need for further research to examine the relationship between national development priorities and adaptive capacity at the household level, including understanding how policies interact to shape autonomous agricultural adaptation options available.

Chapter 8 Discussion: Understanding smallholder farming systems, adaptive capacity and climate change: Insights for adaptation planning

The purpose of this chapter is twofold: 1) to synthesise empirical findings from Chapters 5-7 in a holistic way to advance understanding of farming systems, adaptive capacity, and adaptation; and 2) to situate findings within the literature and reflect on the broader implications for adaptation planning. In doing so, it highlights the benefits and contribution of using a mixed-methods, multi-level approach to explore smallholder farming systems, adaptation, and climate change. Research objectives 1-3 are revisited and synthesised in Section 8.1 and initial insights for adaptation planning are summarised (addressing Objective 4). Section 8.2 reflects on the mixed-methods, multi-level approach. Section 8.3 synthesises findings and discusses the implications for advancing the FSAC framework, where a number of trade-offs are also identified. Section 8.4 summarises the implications for agricultural modernisation policies, whilst Section 8.5 examines the links between autonomous, planned and policy–driven adaptation. Finally, Section 8.6 draws out the implications for adaptation planning, including the case for mainstreaming adaptation, therefore completing the achievement of research objective 4.

8.1 Revisiting the research objectives

This thesis has four interrelated research objectives which contribute to the aim of advancing understanding about the adaptive capacity of smallholder farming in the context of climate change. Up to this point, research objectives 1-3 have been addressed in the results chapters. Findings related to each research objective are summarised in Table 8.1 along with some initial insights into research objective 4, which is addressed further in Section 8.6.

Table 8.1 Summary of key findings related to each research objective

Research Objective	Summary of key findings
1: To explore trends in farming system evolution from the 1960s to 2012 and assess the impacts on farming system adaptive capacity (Chapter 5)	1. Multiple pressures and opportunities have influenced the evolution of farming systems in Uganda. 2. Similar trends in farming system evolution have had differential impacts on the diversity of farming systems, depending on the way that modern farming has been integrated. 3. Trends have contributed to the erosion of informal social and cultural institutions and led to increasing dependence on formal institutions. 4. Trade-offs between components of adaptive capacity are made at the farm-level, thus influencing broader farming system adaptive capacity.
2: To investigate household level responses to past climate hazards (changes, variability, and extreme events) 1960 to 2012 and analyse how adaptive capacity has been operationalised (Chapter 6)	1. Farmers have historical experiences of responding to a range of climate hazards. 2. Variations in levels of adaptive capacity demonstrate that individual farm households respond in different ways when exposed to climate hazards. 3. Household adaptive capacity depends on resource access and the institutions that shape the ways in which resources are accessed and utilised. 4. Resource access and utilisation is mediated by interacting market, civic and public institutions operating at and across different scales. 5. Farmers who are able to maintain flexibility and diversity at the farm-level following exposure to a climate hazard are better able to respond to future climate hazards.
3: To examine autonomous agricultural adaptations to 2030s' rainfall scenarios and assess the extent to which such adaptations are supported by current policy (Chapter 7)	1. Farmers would adapt their systems of farming in a number of ways in response to 2030s' rainfall projections. 2. Similar on-farm adaptations categorised as specialisation, intensification, diversification and extensification were identified, resulting in four groups of farmers. 3. Comparing across the four groups highlighted diversity in household responses to future rainfall projections, demonstrating that multiple trajectories of agricultural adaptations could exist under future rainfall scenarios. 4. The diversity of agricultural adaptations is not recognised or supported by current polices, which in turn risks marginalising certain groups of farmers. 5. Climate change and adaptation are not fully considered in national agricultural and development policies in Uganda.

Research Objective	Summary of key findings
4: To identify insights from using a mixed-methods, multi-level approach for adaptation planning (additional insights presented in Section 8.6)	1. Mixed-methods and multi-level investigations are vital in informing adaptation planning because they generate historical and contextual data as well as in-depth insights into the dynamic and complex nature of adaptation. 2. Agricultural policies and programmes should foster resource and on-farm diversity (Chapter 5 and Chapter 6); and thus move away from a one-size-fits-all approach. 3. Inclusive formal and informal institutions are needed to support adaptive capacity (Chapter 5 and Chapter 6). 4. Adaptation planning should support a range of adaptation options and trajectories, rather than identifying optimal solutions (Chapter 7). 5. Adaptation planning should be mainstreamed into sectoral planning (Chapter 7).

The integrated FSAC framework applied in Chapter 5 provided a starting point for identifying and understanding the evolution of farming systems and how this shapes current adaptive capacity (resources, institutions, productivity and diversity). Chapter 6 provided insight into household level responses to past climate hazards, where the biggest difference to emerge was the ways in which households modify their agricultural practices in response to climate hazards. In Chapter 7, farmers were grouped according to the number and the nature of autonomous agricultural adaptations to 2030s' rainfall projections, resulting in four groups. Findings suggest that that farmers would use a range of autonomous agricultural adaptations, yet this range of responses is not supported by current agricultural and adaptation polices. Whilst specialisation and intensification are consistently supported by policies, diversification and extensification are not. In practice farmers use a combination of these strategies to respond to changes in rainfall. These findings provide an important first step in starting to identify who is benefitting from existing policy support and who may be marginalised under future rainfall scenarios. Further empirical evidence is needed on these issues.

8.2 Reflection on the mixed-methods, multi-level approach

The research design and methodology employed in this thesis, informed by system-thinking, was able to capture the dynamic nature of farming systems and the diversity within and between farming systems. Focussing on two farming systems as case studies, allowed in-depth insights to be drawn. Additionally, it has demonstrated the potential to use farming systems as both a framework and a unit of analysis. The focus on different levels and different points in time using a variety of methods has advanced understanding of the relationship between individual farm systems and farming systems.

The pragmatic framing of this research to include multiple perspectives and multiple methods, enabled the complexity and dynamic nature of farming systems and adaptation to be explored. This resulted in the identification of similar characteristics between individual farm systems making it possible to characterise farming systems in a particular location, demonstrating the benefits of using a multi-level approach. Using a range of methods also generated insights into autonomous agricultural adaptation to 2030s' rainfall scenarios. This enabled the identification of important factors operating across time and space to be fully explored, specifically the role of formal institutions in shaping both adaptive capacity and adaptation. This could not have been achieved by individual methods or focussing on single time horizons and/or levels.

Participatory methods provided crucial insights into how farming systems have evolved, how farmers have responded to climate hazards and the relationship between planned, policy driven and autonomous agricultural adaptations. The participatory methods provided a means to identify important local level factors and capture locally-held knowledge that is not always included in national-level policy processes. Policymakers and researchers are increasingly recognising the importance of locally-held knowledge and experience in shaping the ability of systems and populations to adapt to future climate changes (Antwi-Agyei et al., 2014, Raymond et al., 2010, Whitfield and Reed, 2012). Therefore, this thesis captures important locally-held knowledge that can potentially feed into future planning at the national and sub-national level.

The combination of methods used in this research provided historical and contextual data as well as in-depth insights into the dynamic and complex nature of farming systems and adaptive capacity. It also enabled analysis of linkages across different levels, specifically advancing understanding of the interactions between components of adaptive capacity.

Use of different methods (i.e. household survey, focus groups, interviews, and policy analysis) also provided an important way to triangulate the research findings. As highlighted in Section 4.3.7.6, using a mixed-methods approach can provide additional benefits as a means to triangulate and verify collected data. Using a combination of methods enabled this study to collect data despite challenges with using a particular method. Collecting valid and reliable data not only requires selecting appropriate methods, but also requires spending time in communities to build trust.

Using participatory tools and 2030s' rainfall scenarios to explore incremental changes in rainfall addressed an important gap in the literature. The approach facilitated discussions about the onset, amount and cessation of rainfall, however it was limited in its ability to capture rainfall and temperature extremes. Discussing this during the interviews, participants highlighted that information about the number of rainy days expected each month would be useful in informing on-farm decision-making. This could be taken on board to enhance this method in the future, for example by providing information about number of rainy days each month, rather than only providing monthly rainfall totals.

In summary, using a combination of methods provided insights that could not have been achieved by using a single method alone. This combination captured multi-level dynamics across different points in time, which has importantly advanced understanding about smallholder farming systems, adaptive capacity and adaptation.

8.3 Advancing the farming system adaptive capacity framework

The literature identifies that strengthening farming system adaptive capacity requires consideration of resources and institutions (system inputs) and productivity and diversity (system properties) (Fraser et al., 2011, Quinn et al., 2011, Gunderson and Holling, 2002). This thesis used this conceptual understanding of farming system adaptive capacity to develop the FSAC framework (Figure 2.2). The FSAC framework was used to organise and analyse empirical data generated by the mixed-methods, multi-level approach. Importantly, the empirical findings can also be used to advance the FSAC framework to consider a wider array of factors that are currently overlooked in other studies of farming systems and adaptive capacity. This section will highlight particular parts of the advanced FSAC framework to synthesise findings from across the three results chapters in order to advance understanding about smallholder farming systems and adaptive capacity in the context of climate change.

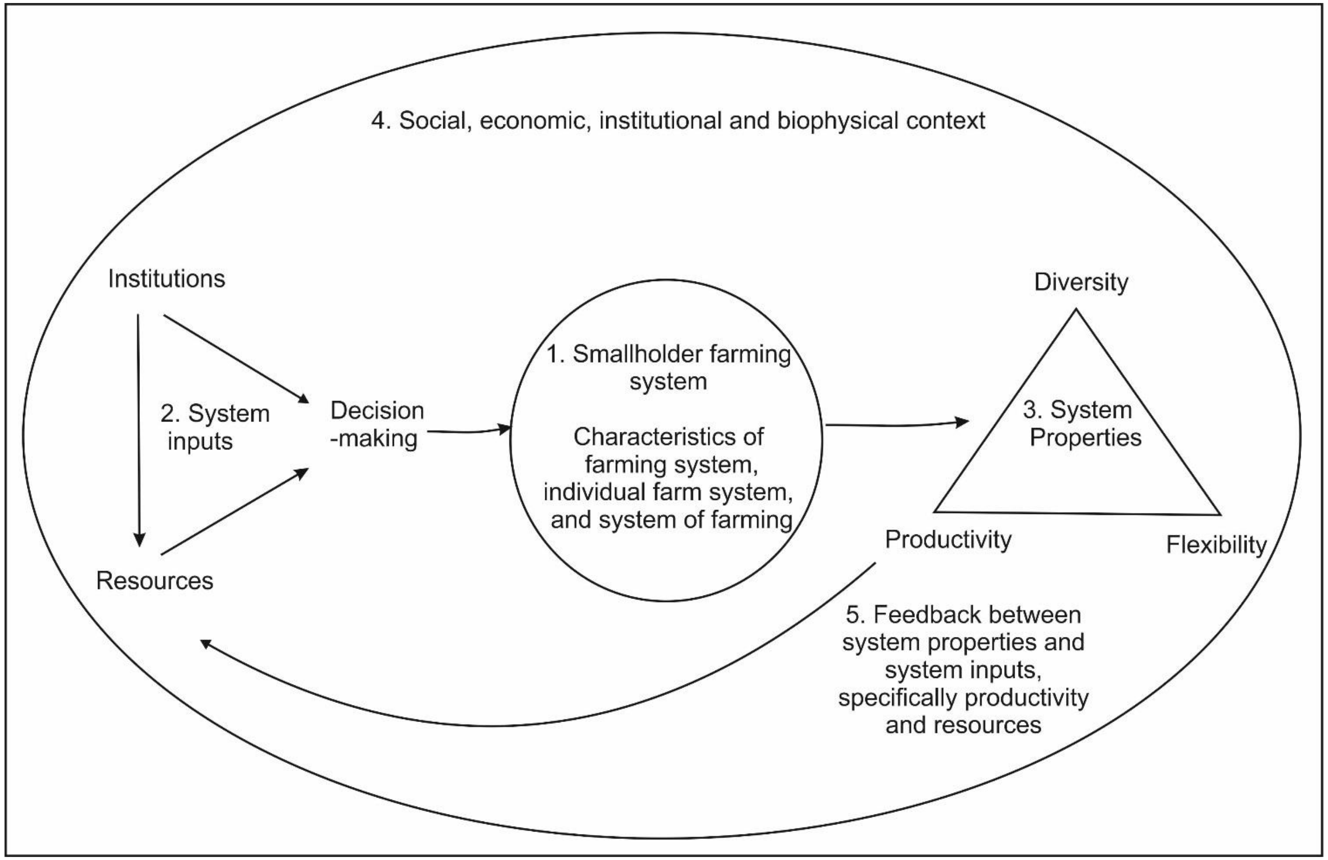


Figure 8.1 Advanced farming system adaptive capacity framework which highlights the importance of farmer decisions and how they interact with resources and institutions to influence the characteristics of the farming system, and in turn how this shapes system properties.

Arrows represent the direction of relationships between factors as demonstrated by empirical evidence provided in this thesis. Additionally, this advanced framework provides a starting point for further studies into the relationships between productivity, diversity and flexibility.

8.3.1 Smallholder farming systems

There is a growing interest in the sustainability of smallholder farming systems (Herrero et al., 2014, Livingstone et al., 2011). Yet, as the literature review highlighted, farming system classifications are based on out-dated empirical evidence (Chapter 2). This section focuses on Part 1 in Figure 8.1 to synthesise thesis findings and demonstrate advances in understanding about smallholder farming systems. Approaches to understanding of farming systems used in this thesis build on previous work highlighted in Section 1.3 (Sumberg et al., 2013, Giller, 2013, Darnhofer et al., 2012, Dixon et al., 2001).

Using a systems approach enabled the dynamic nature of farming systems to be explored at different levels, for example, by focusing on the farming system level in Chapter 5 and household level in Chapters 6 and 7. Analyses also covered various points in time, examining the period 1960-1980 and 1990-2012 (Chapter 5). Adopting this approach a number of patterns at the farming system level emerged. Chapter 5 identified patterns in the range of crops cultivated within each farming system, for example cassava, sorghum, and sesame in SFS, while maize and beans were more prominent in JFS. Chapter 6 highlighted similarities in the nature of household responses, for example, the dependence on market exchanges in Jinja District and storage in Soroti District. Chapter 7 demonstrated the important role of market access in shaping autonomous agricultural adaptations in Jinja District (predominantly by Groups 1 and 2), and social networks that enable autonomous agricultural adaptations in Soroti District (predominantly by Groups 3 and 4). Such patterns in resource use and institutional context can be used to structure farm typologies or identify characteristics of smallholder farming systems (Tittonell et al., 2010, Dixon et al., 2001).

Empirical findings also provided detail about the differences between individual farm systems within a farming system. Individual farm systems are influenced by factors operating at different scales and across policy levels. Farmer decision-making also plays a central role in how resources are allocated at a farm-level, which has implications for the farming system (Chapter 5). This highlights the importance of recognising the cross-scale interactions, and thus the complexity and diversity, within farming systems. It also provides empirical evidence to support Giller's (2013) conceptualisation of farming systems as comprising diverse individual farm systems and their interactions.

Grouping farmers according to the nature of the farm system (from subsistence to market-oriented production) and their autonomous agricultural practices enabled similarities between individual farms within the same farming system to be identified. These commonalities represented similar systems of farming and could be used to identify typologies of adaptation strategies (Zorom et al., 2013). This demonstrates the potential of using systems of farming as a way to understand farming system complexity, and advance understanding of local level adaptation. Additionally, grouping households within a farming system according to their systems of farming offers a way to both recognise the heterogeneity of individual farms (Giller, 2013), and identify any similarities (Dixon et al., 2001). Empirical findings presented throughout this thesis therefore contribute to wider debates about the relationship between farming systems, farm systems and systems of farming (Whitfield et al., in press) .

Evidence presented in Chapter 5 confirms the need to move beyond the narrow framing of farming systems as production systems. For example, this thesis has revealed that farming systems provide: crops for making local brews, food for human consumption, resources that can be informally traded, and income from the sale of crops and livestock. This highlights that farming systems fulfil multiple objectives: they provide food security, environmental functions, economic functions, and social functions (Tipraqsa et al., 2007). Such objectives cannot always be quantified in terms of productivity and profitability (Klapwijk et al., 2014). This finding links to broader ideas about the multi-functionality of farming systems (Kremen et al., 2012). This thesis therefore supports calls for greater consideration of multi-functionality in farming systems research (Horlings and Marsden, 2011, Kremen et al., 2012).

Together, empirical findings from the results chapters contributed to our understanding of farming systems. They highlighted the importance of: 1) considering the wider context in which farming systems are situated; 2) farm-level decision-making in determining the systems of farming; and 3) the multi-functionality of farming systems. These three findings should be integrated into future research into smallholder farming.

8.3.2 System inputs: resources, institutions and decisions

This section focuses on Part 2 in Figure 8.1. Specifically, it synthesises empirical findings related to the relationship between resources and institutions, and calls for the inclusion of decisions as system inputs in farming systems adaptive capacity.

Chapter 5 identified a number of important differences between the JFS and SFS in how resources were accessed and utilised within each farming system. These differences can partially be explained by the interplay between various institutions and how they influence resource access and utilisation at the household level. This interplay shapes how households access and manage resources. Studies have shown the importance of institutions in influencing adaptive capacity (Berman et al., 2012) and in shaping farming system adaptive capacity (Fraser et al., 2011).

Evidence from this research has provided additional insight into how institutions can change over time (Chapter 5), how this influences the ways in which resources are operationalised (Chapter 6) and how they may shape agricultural adaptation to future rainfall projections (Chapter 7). Discussing similarities and differences in Chapter 5 demonstrated that institutions are context specific in the way that they can shape resource access and utilisation. For example, changes in government policies since 1960 contributed to the erosion of cooperatives and an increase in individual market exchanges. In the JFS, such market exchanges are used to respond to recent (last 5 years) climatic and non-climatic hazards and are replacing traditional practices such as saving food and seeds. This change in how resources are used at the household level means that households are increasingly dependent on buying food and seeds. However, in the SFS, evidence of traditional practices, such as food storage, suggests that informal civic institutions are still important for both household level and farming system adaptive capacity. These findings demonstrate the importance of the institutional context in explaining differences between farming systems and show how institutions can link local systems to factors operating at larger scales (Agrawal, 2008). Whilst the role of institutions in shaping adaptation is well established in current studies of adaptation (Antwi-Agyei et al., 2014, Osbahr et al., 2008a, Wang et al., 2013), such institutional dynamics are often overlooked in FSR, which predominantly focuses on biophysical factors and processes (Cortez-Arriola et al., 2014, Esilaba et al., 2005, Kalaugher et al., 2013). To better understand the dynamic and complex nature of farming systems, future FSR should explicitly consider institutional factors and dynamics. The importance of institutional factors and processes highlighted throughout this thesis offers an important contribution to understanding the human dimensions of farming systems and their ability to adapt to climate change and variability.

As highlighted in Chapter 5, household-level decisions are important for individual farm and farming system adaptive capacity, thus justifying the focus of Chapter 6 and Chapter 7. Decisions explored in this thesis include past livelihood adaptations to climate hazards (Chapter 6) and autonomous agricultural adaptations to 2030s' rainfall projections (Chapter 7). Interrogating farmer decision-making captured the diversity of actions that underpin adaptation (Osbahr et al., 2010, Thomas et al., 2007) and also provided additional insight into the direct and indirect interactions between resources and institutions, and how they influence decisions. These interactions are represented by the arrows in Part 2 of Figure 8.1, which demonstrates that institutions directly influence resources. For example, markets (private institutions), affect the kinds of agricultural inputs that are available. Institutions can also indirectly influence how resources are accessed and utilised through shaping farmer decision-making. For example, cultural norms (informal institutions) may influence food preferences that in turn influence decisions that determine which crops are planted and therefore how resources are used. These findings highlight the importance of decision-making in linking resources and institutions. This thesis therefore suggests that decision-making is a fundamental component of farming system adaptive capacity. Incorporating decision-making into the FSAC framework has the additional benefit of recognising the capacity of people (acting individually and collectively) which is often overlooked in systems approaches (Folke, 2006, Leach, 2008).

In summary, this thesis recognises that resources, institutions and decision-making are individual, but related components, of farming system adaptive capacity, embedded in the wider social, economic and biophysical context (Part 4 in Figure 8.1). Interactions between resources, institutions and decisions are influenced by the wider social, economic and biophysical context (Bebbington, 1999, Forsyth and Evans, 2013, Giller et al., 2006) and also shape the characteristics of smallholder farming, at both the individual farm system and broader farming system level (Part 1 in Figure 8.1). Identifying and exploring the interaction between resources, institutions and decisions has advanced the frameworks of Fraser et al. (2011) and Quinn et al. (2011), and has identified additional important components of farming system adaptive capacity. Decisions are now captured in the advanced FSAC framework (Figure 8.1), which previously only included interactions between resources and institutions. Decisions are connected to both resources and institutions, highlighting direct and indirect interactions between these components.

8.3.3 System properties: productivity, diversity and flexibility

This section focuses on Part 3, 4 and 5 in Figure 8.1 and also highlights the interconnectedness with other parts of the framework.

Existing studies demonstrate the importance of diversity and productivity in maintaining the adaptive capacity of farming systems (Quinn et al., 2011, Fraser et al., 2011), justifying the inclusion of these properties in the original FSAC framework (Figure 2.2). This section focuses on empirical findings about system properties (Part 3 of Figure 8.1), and suggests that flexibility is an important system property to include in future studies. Furthermore, in response to findings in Chapter 7 about the temporal connections between system properties and inputs, this section explores this relationship further (Part 5 of Figure 8.1).

The characteristics of farming systems shape the system properties, i.e. system properties are linked to the nature of crop and livestock production, and other natural resource based and off-farm activities (Part 1 in Figure 8.1). Over time, farming system properties change in response to multiple pressures and opportunities, for example biophysical factors such as changes in weather, pests and diseases, and human factors such as changes in policies (Keating and McCown, 2001). They are also influenced by the broader context of socio-economic and environmental change (Thomas et al., 2007).

System properties are important components of adaptive capacity because they can influence future resource availability and accessibility, highlighting the temporal dimensions of adaptive capacity which is now captured in the advanced FSAC framework (Figure 8.1). In particular this thesis has demonstrated feedback between productivity and resources (Part 5 in Figure 8.1). For example, crop productivity will influence the amount of food, income, seeds, available to meet household needs in the future (Chapter 7). Additionally, food, income and seeds provide important resources for future cultivation and/or resources that can be exchanged (formally through markets or informally through social networks) for agricultural inputs and on-farm labour. These are also important resources that enable responses to climate hazards expected under future climate change and variability.

Efforts to maintain farming system productivity have undermined diversity in the JFS, whereas diversity has been maintained in the SFS. Similarly at the household level, response diversity has been maintained in Soroti District, but undermined in Jinja District, where farm households are dependent on market exchanges to respond to both climatic and non-climatic hazards (Chapter 6). The potential trade-offs between productivity and diversity are discussed further in Section 8.3.4. Empirical findings presented throughout this thesis and other studies demonstrate a close relationship between flexibility and diversity (Kremen et al., 2012, Tittonell et al., 2010, Darnhofer et al., 2010). Therefore, to advance our conceptual understanding of farming system adaptive capacity and the work of Quinn et al. (2011) and Fraser et al. (2011), flexibility has been integrated into the farming systems adaptive capacity framework as an important system property (Figure 8.1), alongside diversity and productivity.

Exploring the relationship between past exposures to pressures and opportunities and adaptive capacity revealed that maintaining flexibility, at both individual farm (Chapter 6) and farming system level (Chapter 5), is important in fostering future adaptive capacity. Empirical evidence from Chapters 6 and 7 suggests that reduced diversity undermines flexibility. As highlighted in the wider literature and confirmed by empirical findings (Chapter 6 and Chapter 7), farmers with less flexibility have fewer options to respond to future pressures and opportunities, including climate change and variability. This suggests that flexibility is an important system property, as undermining it can exacerbate or create vulnerability and reduce adaptation options (Coulthard, 2008, Fazey et al., 2009). In Jinja District, flexibility has been undermined by the erosion of traditional practices, the shift towards market-oriented agriculture and the resulting dependence on market exchanges. This raises questions about the assumed benefits of further integration between smallholder farming and commodity markets (Paavola, 2008), and thus supports existing calls for fostering market settings that offer flexibility as well as low risk, high returns (George, 2014). Market integration is currently promoted through agricultural modernisation policies in Uganda (MAAIF, 2011), but limited attention is given to the broader impacts on flexibility, diversity and adaptation options.

System properties (productivity, diversity and flexibility) are interconnected. For example, as demonstrated in the SFS, cultivating a diverse range of crops contributes to productivity, and if a climate hazard is experienced that affects productivity of a particular crop, then other cultivated crops may be unaffected. These unaffected crops may be drawn upon and used to support household needs or wider livelihood activities, demonstrating that flexibility can be created through on-farm diversity; compare this with the JFS, where mono-cropping is more common (Chapter 5) and a smaller range of crops is cultivated at the farm level (Chapter 7). If a climate hazard is experienced and it affects the cultivated crops, then households have fewer options to draw upon other crops, i.e. less flexibility. The relationship between diversity and flexibility, clearly demonstrated in this thesis sets the foundations for further research into the empirical relationships between productivity, diversity and flexibility.

Overall, empirical evidence in this thesis demonstrates the interconnectedness of system properties. However, the exact nature of the relationship between them is unclear and may involve potential trade-offs (see Section 8.3.4). This ambiguous nature of the relationships between productivity, diversity and flexibility justifies why arrows are not included for system properties (Part 3 of Figure 8.1) and highlights an area for future work.

8.3.4 Trade-offs between productivity, diversity and flexibility

Empirical findings presented throughout this thesis has demonstrated that a range of actors at different levels, including individual farmers, households and national and sub-national policy-makers, make decisions that involve a number of trade-offs. By focussing on different points in time and space, this thesis provides insight into trade-offs made by decision makers at different levels and between components of adaptive capacity, and thus, it offers an empirical contribution to trade-off debates.

Findings from JFS highlight trade-offs between productivity and maintaining flexibility and diversity made at the farming system and individual farm level. Productivity, diversity and flexibility have been maintained in the SFS, and therefore, individual farms possess higher levels of adaptive capacity than the JFS. The higher levels of adaptive capacity found in SFS suggests that farm households may be better able to adapt to future climate hazards (Chapter 6). However, Soroti District has higher poverty levels and lower levels of socio-economic development than Jinja District (Rogers et al., 2006), highlighting that high levels of adaptive capacity have not translated into poverty reduction or socio-economic development. Jinja District has higher levels of socio-economic development, indicated by ownership of mobile phones, radios and permanent houses (Chapter 5). Asset accumulation has been generated by producing and selling cash crops, such as sugarcane, but this has undermined diversity and flexibility, highlighting a potential longer term trade-off in favour of short term productivity. Over time this trade-off can reduce adaptive capacity at both the household and farming system level (Chapter 5 and 6). This implies a potential trade-off between maintaining flexibility and diversity, important for adaptive capacity, and short-term productivity. These findings emphasise the need for analysing trade-offs between short-term and longer-term productivity, flexibility, and diversity, highlighting the importance of temporal dimensions of capacity (Giller et al., 2006).

Trade-offs between productivity and diversity are reflected in both government agricultural policies (Chapter 7) and in programmes being implemented by NGOs (Chapter 5). Government agricultural modernisation policies prioritise productivity, yet can reduce the diversity and flexibility of farming systems (Chapter 5), or shift vulnerability by increasing exposure to other risks such as market fluctuations (Chapter 6), thus potentially undermining future farming systems (Chapter 5) and household level (Chapter 6) adaptive capacity. This demonstrates that policies support particular systems of farming and agricultural adaptations, which can lead to on-farm trade-offs between productivity, diversity and flexibility. For example, a range of government policies and NGO programmes in Uganda currently promote agricultural modernisation, through specialisation (reduction in the number of activities, animal breeds and crops cultivated at the farm-level) and intensification (increasing productivity from the same farm by spending longer or working harder to maintain the same returns).

Current agricultural modernisation policies in Uganda trade-off system properties (productivity, diversity and flexibility) between the local and national level. For example, diversifying the national economy has resulted in both farming system and individual farm specialisation. Specialisation is undermining flexibility and diversity which concurs with other studies of farming systems (Conway, 1993, Giller et al., 2011, Klapwijk et al., 2014). If a policy is implemented in the national interest, for example to promote national economic development, but is expected to have negative impacts at a sub-national level, then such trade-offs should be made explicit and measures put in place to minimise negative local level impacts.

Increasing specialisation as a strategy to promote agricultural modernisation could reduce the ability of the farming system and individual farms to adapt to future changes. To address this, APZs could promote on-farm diversification, rather than specialisation, as a means to diversify the national economy. Furthermore, adaptation planning could consider alternatives to specialisation, such as developing flexible production systems (Rogerson, 1994), as a means to achieve national development goals whilst maintaining flexibility. This could foster adaptation and development across space and time (Vincent, 2007) and thus highlights the potential for synergies between adaptation and development policies.

Thesis findings suggest a number of trade-offs are made across scales by multiple actors, including policy makers and farmers acting both individually and in aggregate. Trade-offs have been overlooked by current agricultural modernisation policies, which have also been criticised for serving certain political agendas, linking to particular forms of agricultural development-led industrialisation which promote specialisation and intensification (Milman and Arsano, 2014). This raises questions about the suitability of existing goals, policies and programmes in Uganda (Bahiigwa et al., 2005). Findings concur with other studies of agricultural development-led industrialisation models across SSA. Policy-makers across SSA should identify where differential impacts across space and time are likely and seek to reduce potential trade-offs. Incentives should be structured in a way that does not require farmers to discount the future or choose between adapting to climate changes and socio-economic development. This has particular relevance for strengthening adaptive capacity in the face of future climate change and variability.

In the context of future climate uncertainties and existing development challenges, this thesis supports the need for further empirical evidence into the relationship between adaptation and development at the household level as identified in the literature (Conway and Schipper, 2011, Huq and Reid, 2004, Mertz et al., 2009). We need to better understand trade-offs and potential complementarities between enhancing development in the short term and maintaining or strengthening longer term adaptive capacity, and within this, the role and decision-making processes of a range of actors including farmers and policy makers. If not addressed, on-farm trade-offs between maintaining adaptive capacity and productivity may impact upon poverty reduction and household level development (Béné et al., 2014), as well as limiting national economic development.

8.4 Agricultural modernisation policies

At a local level, this thesis shows that agricultural policies in Uganda support certain farmers, such as those pursuing intensification and specialisation (Chapter 7), without considering how the costs and benefits are locally distributed. Policies supporting specialisation and intensification are linked to international discourses surrounding the impacts of agricultural modernisation as a means of economic growth (Horlings and Marsden, 2011). Agricultural modernisation is highly standardised, large-scale, mechanised and reliant on relatively few uniform cultivars. Historical analysis of farming systems identified that agricultural modernisation has been promoted as a vehicle for economic growth since the 1980s (Chapter 5) and underpins current agricultural policy (Chapter 7). It has been promoted in Uganda since the 1980s' agricultural policy reforms required by structural adjustment programmes (Belshaw et al., 1999). Issues surrounding agricultural modernization have been investigated by others (Bahiigwa et al., 2005) and they have been a matter of contention in Uganda, as in economies across SSA (Bellon and Hellin, 2011). Therefore, findings about the relationship between agricultural modernisation and adaptive capacity presented in this thesis have potential policy relevance both within Uganda and across SSA.

Agricultural modernisation policies are targeted at smallholder farmers and are expected to increase productivity and generate income at both the local and national level (MAAIF, 2010b). However, evidence presented in this thesis suggests that such strategies can have a negative influence on adaptive capacity (Chapter 5), specifically if it undermines the availability of future resources or on-farm diversity. For example, NGO and government programmes focus on technological adaptations to increase short-term crop and livestock productivity at the local level. This is expected to have aggregate wider developmental benefits at a national level. However, in some cases providing technology and resources (e.g. agricultural inputs) to farmers has undermined adaptive capacity, for example by reducing diversity and flexibility. Other studies also highlight that such technological solutions have not had the intended impacts on productivity (Friis-Hansen et al., 2004) and policies can overlook the wider social and environmental impacts (Bos, 1992, Stoop et al., 2002).

Technology adoption can increase productivity locally (Feder and Umali, 1993) and contribute to aggregate productivity gains at wider spatial scales (Huang and Rozelle, 1996). But, technological solutions can reduce on-farm diversity, as in the case of the JFS, and have longer-term negative impacts on resources and institutional arrangements that shape future adaptive capacity. For example, shifts towards agricultural modernisation have contributed to the erosion of local level informal institutions in JFS, whereby households no longer exchange labour for seeds or food. Instead, households rely on market exchanges, buying seeds and food (Chapter 6). This also has important implications for resource use because modern inputs (including seeds) require money or other substitutable resources, as modern seeds cannot be replanted repeatedly as they fail or produce significantly reduced yields (George, 2014). Additional demands on household resources in the short term can reduce the availability of resources in the future, and thus over time can undermine household adaptive capacity. Efforts should be made to identify and foster inclusive informal institutions at the local level that support households to have continued access to resources, such as seeds, labour etc.

Maintaining or strengthening diversity and flexibility will be important in the context of future climate change and variability (Fazey et al., 2009). Given that these are being undermined by current agricultural modernisation policies, this thesis questions the suitability of existing policies and identifies the potential to rethink how agricultural modernisation is implemented in practice (Chapter 7). Other studies demonstrate the potential for alternative approaches to modernisation, for example, agro-ecological approaches that incorporate principles of ecological knowledge, such as intercropping and crop rotation (Horlings and Marsden, 2011, Thompson, 2007). Conservation agriculture, promoted across southern Africa, offers further potential to be explored; although current studies suggest a limited understanding of the suitability and transferability of conservation agriculture across agro-ecological zones (Andersson and D'Souza, 2014). Alternatively, agricultural modernisation in Uganda could integrate principles and processes such as diversity and flexibility alongside productivity as a way to foster adaptive capacity. Exploring alternative approaches to agricultural modernisation (see Horlings and Marsden, 2011 for more specific alternatives) could lead to multiple initiatives and policies appropriate for the diverse farming systems across SSA, and thus represent a move away from one-size-fits-all approaches (Giller, 2013). Ignoring the negative, and perhaps unintended, consequences of agricultural modernisation on adaptive capacity could lead to further unequal, less-than-optimal material and social outcomes (Carr, 2008).

8.5 Planned adaptation, autonomous and policy-driven adaptation

Links between autonomous and planned adaptations explored in Chapter 7 demonstrate a relationship between institutions, decisions and resources (Part 2 in Figure 8.1). This will be further explored in this section.

The climate change adaptation literature distinguishes between autonomous and planned adaptations (Smit et al., 1999). Planned adaptations (a type of formal institution) tend to be driven by policy makers and can occur at various governance levels, whereas autonomous adaptation decisions are generally considered to take place at the local level (Stringer et al., 2009). Planned adaptation has received increasing attention in response to concerns that autonomous adaptation is inefficient and could lead to maladaptation (Suckall et al., 2014b). Planned adaptation provides a way to reduce the risk of maladaptation (Suckall et al., 2014b).

Chapter 7 demonstrates that there is little evidence of planned adaptation in Uganda. Planned adaptation policies are in their infancy, demonstrated by the limited implementation of the NAPA (Chapter 7). Such findings are comparable with other countries in SSA (Sietz et al., 2011) and other studies that identify adaptation policy gaps (Brown, 2011, Conway and Schipper, 2011). Implementation of planned adaptation such as NAPAs, which are being replaced with National Adaptation Plans (UNFCCC, 2014a), is essential to guide adaptation to climate change and variability.

Although planned adaptation in Uganda is in its infancy, this thesis as a whole has identified a number of ways in which other sectoral policies have influenced local-level adaptation decisions. Historical evidence reveals that government and NGO agricultural policies have influenced farming systems in Uganda. For example, Chapter 5 notes the influence of formal institutions on changes in crop cultivation and management decisions. Additionally, Chapter 6 demonstrates that agricultural adaptations undertaken by farmers in response to past climate hazards, such as cultivating new crops, varieties and breeds, is influenced by agricultural policies that have both promoted the use of, and supplied, new crop and livestock breeds. Current government agricultural policy identifies specific crop and livestock enterprises for each region according to the APZ and therefore directly influences management decisions (Chapter 7).

Findings from the results chapters (Chapters 5-7) demonstrate that local and national level policy decisions can drive adaptation. Additionally, policies can shape autonomous agricultural adaptation by supporting or promoting specific strategies, such as intensification and specialisation (Chapter 7). These examples are not planned adaptations, but are policy-driven. Policy-driven adaptations, such as those influenced by agricultural modernisation policies, are not always intended or successful in reducing vulnerability or taking advantage of potential opportunities. This thesis therefore reveals that policy-driven adaptations exist, but that they may not be specific planned adaptation policies that reduce the risks of climate change and variability.

Policy-driven agricultural adaptations can create new vulnerabilities at the local level. For example, market-oriented farmers in Jinja District have intensified and specialised their systems of farming, supported by current agricultural policies. Such strategies can improve household income, but they can increase food shortages at the household level and leave households dependent on market exchanges over which they have no control. This is exposing farmers to other hazards, such as market hazards, and reducing their ability to respond in the long term, i.e. it is undermining future farming system adaptive capacity. This results in shifting vulnerability, rather than overcoming it, and can therefore be described as maladaptive (Vincent et al., 2013). Shifting vulnerability at the local level is not reflected in the current conceptualisation of maladaptation proposed by Barnett and O'Neill (2010) and therefore highlights an area for future investigation.

These findings highlight a broader link between formal institutions, such as government policy, and local level decision-making. By influencing local level decisions and resource access, policies both directly and indirectly shape the adaptation options available to farmers. Such findings confirm that adaptation to future climate changes will be influenced by the wider policy and institutional context (Wang et al., 2013, Twyman et al., 2011). These links support other studies of adaptation in SSA (Stringer et al., 2009). Creating an enabling institutional environment to support adaptation options could help avoid what Darnhofer (2014) refers to as the incremental adaptation trap, where autonomous adaptations provide short-term relief that maintains the status quo and inhibits adaptability and transformability in the long term (Gunderson et al., 2006, Stringer et al., 2014).

Links between decision-making, resources and institutions demonstrate that seemingly autonomous decisions are rarely autonomous, i.e. they are influenced by the wider institutional context and can be the result of planned policy interventions. The literature also highlights the importance of the broader socio-economic and environmental context in shaping autonomous adaptation decisions (Forsyth and Evans, 2013). Recognising that autonomous adaptation is influenced by institutional, socio-economic and environmental factors, and in some cases can be the result of planned policy interventions, is crucial. Failure to do so results in an oversimplification of how smallholder farmers respond to climatic changes (Forsyth and Evans, 2013). This also makes it difficult to isolate individual drivers of adaptation (Thomas et al., 2007), and as such may make it difficult to identify specific climate adaptations, as suggested in recent climate change literature (Lobell, 2014). This thesis therefore raises questions about the distinguishing features of autonomous adaptation and supports calls for further critical reflection on the concept of autonomous adaptation (Forsyth and Evans, 2013). Additionally, such findings confirm that broad conceptualisations of adaptation are needed to adequately capture the complex reality in which adaptation takes place (see for example Stringer et al., 2010).

8.6 Implications for adaptation planning

As mentioned in Chapter 3, case study research findings are not always generalizable or transferable across different contexts. To address this challenge, this section will draw upon the key insights from this thesis and situate them in the broader context in order to identify the implications for adaptation planning. This section summarises how the advanced understanding of farming systems and adaptive capacity provided by this thesis could shape adaptation planning at different levels (sub-national and national). This will include implications for a variety of actors who may be involved in adaptation planning at various levels, such as government policy-makers, researchers and NGO practitioners.

8.6.1 Implications for sub-national planning

Currently, insufficient attention has been given to the role of sub-national level policy in adaptation planning (Barrett, 2014), despite this governance level being recognised as important for effective policy implementation (Urwin and Jordan, 2008). In Uganda, the governance at the sub-national level includes the district and sub-county (Section 3.4). Policy support at the sub-national level should be tailored to the local context. For example, policy support in Jinja District needs to reflect the changing attitudes of the youth towards agriculture, and in Soroti District the important role of livestock as part of the SFS must be recognised and supported. This confirms that there is potential to link farming systems to recommendation domains and administrative levels (Collinson, 2000, Dixon, 2000).

The connections between resources, institutions and decisions reveal a need for local level policies to address some of the underlying institutional processes that shape resource access and utilisation. For adaptation planning at a district level, this may require adapting or transforming existing institutional structures to better distribute the benefits of agricultural policies. Additionally, this thesis revealed that a range of non-government actors and programmes operating at the sub-national level has also influenced the evolution of farming systems. This suggests that there is potential for government and non-governmental actors to collaborate further, to ensure synergies and also enhance efficiency and effectiveness (Brinkerhoff, 2002).

Despite Uganda's decentralised system, current policy does not reflect diversity of farming systems or the range of agricultural adaptations that farmers use. Additionally, this thesis has demonstrated that farmers have a range of experience in responding to climate hazards, but that these are not well documented or considered in existing national government policies (Chapter 7). There is thus potential for local level experiences to feed into policy-making at both a national and sub-national level (Cloutier et al., 2014). The sub-county is the lowest level of local government directly involved with both representation and service delivery at a village level and targeting this level could offer an opportunity to integrate local knowledge and experiences (Fraser et al., 2006). Widening participation in policy development could better reflect local priorities and create avenues for appropriate policy support (Whitfield and Reed, 2012). Furthermore, the broader benefits of participation are well established in the literature (Stringer et al., 2006) and may also have the additional benefits of reducing trade-offs between productivity, flexibility and diversity across different levels.

8.6.2 Implications for national level planning: mainstreaming adaptation and implementing planned adaptation

As Chapter 7 highlights, current national agricultural policies in Uganda support a narrow range of agricultural adaptations, such as on-farm specialisation or intensification strategies, which in turn creates potential marginalisation. This means that the benefits of policy support are unevenly distributed and tend to favour farmers who are using such strategies. Additionally policies narrowly focus on productivity and therefore do not support the multi-functional nature of farming systems or other components of adaptive capacity identified as important by this study. Wider evidence suggests that agricultural policies are not necessarily having the anticipated benefits (Kassie et al., 2011, Friis-Hansen et al., 2004). Furthermore, they are undermining farming system and household level adaptive capacity (Chapter 5 and Chapter 6). Findings presented in Chapter 7 show that in Uganda adaptation is yet to be integrated into existing agricultural policies. This concurs with other case studies in SSA (Sietz et al., 2011, Ogallo, 2010, Huq and Reid, 2004) and highlights a need for better integration of adaptation into national agricultural policies, i.e. the mainstreaming of adaptation.

Mainstreaming adaptation into policies could be cost effective and resource efficient, for it would utilise existing structures, rather than creating new ones, and could therefore reduce the development of conflicting policies in different sectors (Suckall et al., 2014a). Additionally, integration of adaptation planning into agricultural policies could also reduce the risk of policy-driven adaptations compromising socio-economic development (Román et al., 2012); thus reducing potential trade-offs between short term development goals and longer term adaptive capacity (as highlighted in Section 8.3.4). Adaptation planning should not only consider the impacts of climate change, but also seek to improve economic and social welfare and thereby improve the adaptive capacity of individuals and communities (Mertz et al., 2009), thus demonstrating the need for mainstreaming adaptation into wider policies.

Although existing agricultural policies pay limited attention to climate change adaptation (Chapter 7), other studies suggest that national development policy could provide an alternative means of implementing planned adaptation and supporting local-level adaptation (Naess et al., 2011). However, the literature recognises that currently there is a lack of incentives for national policy makers in developing countries to integrate adaptation into national level planning (Sietz et al., 2011).

Findings in this thesis therefore provide a case for mainstreaming adaptation planning into agricultural policies in Uganda. Such mainstreaming requires both auditing existing policies and 'climate proofing' new ones so they support rather than hinder adaptation planning (Urwin and Jordan, 2008). Failure to mainstream adaptation not only runs the risk of conflicting policy objectives, but also could lock-in households and farming systems to inflexible trajectories (Chapter 6), thus undermining the ability of households to access and utilise resources in the future (Chapter 7). Lock-ins could reduce the number of future adaptation options, which may be needed to manage future climate uncertainties (Fazey et al., 2009). Reducing options could foster inflexible farming systems and lead to narrow adaptation pathways (Wise et al., 2014, Butler et al., 2014) and increase the potential for maladaptation (Barnett and O'Neill, 2010). National policy makers need to recognise that adaptation to future climate changes may require support for a range of adaptation options and should better enable local communities to respond in their own ways.

As this thesis demonstrates, the future role and impact of planned adaptation in SSA will depend not only on the development of adaptation policies and plans, but also implementation. National adaptation policies can enable and incentivise the implementation of planned adaptation at other policy levels (Oberlack and Eisenack, 2014). However, policy implementation remains a key challenge for environmental governance (Leventon and Antypas, 2012). Sub-national government officials highlighted a number of problems in implementing agricultural policies, for example, poor timing of delivering agricultural inputs, duplication of roles between NAADS and other extension services, conflicting policies and limited coordination with other service providers (NGOs), and delays in fund disbursement. These factors limit the ability of local government to provide effective agricultural extension services. A local government official highlighted this:

> *"The government has very good policies, but implementation, I don't know….you can find in one place we are promoting people to grow crops themselves, then there is another NGO distributing food, so you find that there is no motivation for these people to grow, why do you waste your time in the garden when somebody is bringing you a package of food"*

(Soroti District Local Government Official, Interview, June 2012)

A range of other barriers and opportunities for policy implementation have been identified across SSA, which are especially relevant to new policy domains such as adaptation (Celliers et al., 2013). For example, the literature highlights implementation plans, legal frameworks, human and financial resources as paramount for successful policy implementation (Biesbroek et al., 2013, Sietz et al., 2011, Stringer et al., 2010).

Countries in SSA have been identified as having weak institutional capacities to implement mainstreaming at the national (Sietz et al., 2011) and sub-national level (Brown, 2011), where there is also a potential gap between scientific knowledge and policy-makers' needs (Lemos et al., 2007). This suggests that the successful implementation of National Adaptation Plans will depend on strengthening institutional capacities. Capacity building may be needed at both national and sub-national levels to raise awareness about adaptation (Gandure et al., 2013) and to integrate adaptation into existing planning and policy cycles (Stringer et al., 2014), before implementation can actually occur. This will be strongly influenced by funding and the availability of resources (Dellink et al., 2009).

8.6.3 Broader implications for adaptation planning

Current approaches to developing National Adaptation Plans focus on identifying and responding to climate risks (Conway and Schipper, 2011), also referred to as 'predict and prevent' approaches (Heazle et al., 2013). Such approaches focus on identifying risks and optimal adaptation strategies, where first consideration is given to technical approaches to adaptation and therefore solutions (Noble et al., 2014). Recommendations for agricultural technology adoption can be identified throughout the climate change adaptation literature, for example changing planting date (Challinor et al., 2014b), switching crops (Thornton et al., 2009a), cultivating drought tolerant varieties (Hisali et al., 2011), or substituting livestock for crops (Seo and Mendelsohn, 2007). Such technical recommendations can inform policies and prioritise investments, for example investment in research, biotechnology, or irrigation systems. However, this thesis has demonstrated how such technical recommendations, also referred to as silver bullet solutions, that often aim to optimise production (Armitage et al., 2012) and promote agricultural modernisation (George, 2014), can have differential impacts on adaptive capacity across space and time. For example, the introduction of improved varieties, which may be more tolerant to drought, can require additional farm resources (labour, money) and reduce crop diversity at the farm-level, therefore undermining future adaptive capacity. This challenges the view that technical approaches and solutions will sufficiently address adaptation in SSA (Burney et al., 2014, Lobell, 2014).

Current approaches to understanding the impacts of future climate change and variability on various sectors, including agriculture, also tend to focus on technical solutions and identifying optimal adaptation strategies. In the case of farming systems, technical solutions focus on maintaining and maximising productivity, which this thesis has demonstrated can reduce adaptive capacity in the long term. Technical solutions promoted by current research and policy can both undermine the ability of farmers to respond to climate change and variability and create lock-in to inflexible development trajectories (Gandure et al., 2013).

Modelling approaches, which often form the bases of technical solutions, reduce farming systems to simple productive systems, which this thesis has challenged. Technical solutions, such as adopting new varieties, often overlook the complexity and dynamism of farming systems and the suitability of technical recommendations. To avoid inappropriate recommendations, modelling studies which make such technical recommendations should clearly state the assumptions and under which conditions the recommendations will apply. Furthermore, the institutional processes and the implementation mechanisms that shape the success of technology adoption are rarely considered by such recommendations, which can result in winners, losers, and negative environmental, social or economic impacts across space and time. Overall, this thesis confirms that technical solutions alone will not fix the challenges presented by future climate change (Ericksen et al., 2009, Dessai et al., 2013). This needs to be better reflected in future research, agricultural policies and adaptation planning, which should move away from technological and 'one-size-fits-all' approaches.

Strengthening adaptive capacity provides a way for farmers in Uganda and across SSA to manage the uncertainties around future climate changes (Osbahr et al., 2011). Strengthening adaptive capacity also provides a way for farmers to better deal with current climatic variability and change (Cooper et al., 2008). For example, this thesis demonstrates than fostering a range of adaptation responses may better maintain productivity, flexibility and diversity in the longer term, yet this is not reflected in current agricultural or adaptation policies. Additionally, adaptation planning could instead foster a range of adaptation options in order to avoid locking farmers into maladaptive development trajectories. This may require a rethink of existing planning approaches and national development objectives that better support adaptation options. In the absence of a robust framework to evaluate optimal adaptation strategies and uncertainties around future climate projections, fostering options could reduce the risk of maladaptation (Butler et al., 2014, Wise et al., 2014, Fazey et al., 2009) and offers a tangible way to strengthen farming system adaptive capacity.

A new approach to adaptation planning would require a move away from targeted programmes and optimal strategies to achieve specific goals, outcomes and predetermined targets (Ireland and McKinnon, 2013). Instead, adaptation planning could create an enabling environment to foster the diverse and often spontaneous innovations at the local level (Rodima-Taylor et al., 2012), which are not adequately supported in existing policies and programmes (Ireland and McKinnon, 2013). Additionally, policies that build on and support existing practices may yield faster results and require fewer resources and investments in education, awareness raising and capacity building (Stringer et al., forthcoming). This may, however, require a rethink of agricultural extension services and the way that they support smallholder farmers.

Fostering a range of options provides an alternative to identifying optimal solutions, which tends to dominate current climate impacts studies. Therefore, this thesis suggests that rethinking the role of climate impacts research in providing information for adaptation planning may be necessary. Examples of alternative ways to use climate impacts research and modelling studies are provided in the literature (see for example Challinor et al., 2013, Wesselink et al., 2014). Alternatives could include using models to identify important processes, for example links between El Niño and global production (Iizumi et al., 2014) and/or to identify processes at smaller spatial scales and shorter timeframes (Hansen et al., 2011, Iizumi et al., 2013), which could then be discussed with smallholder farmers (Patt et al., 2005). This could enable a better understanding of the relevant processes that may result in future climate risks for smallholder farmers and also provides a way to engage farmers in exploring adaptation options.

8.7 Summary of Chapter 8

Applying and advancing the FSAC framework has enabled the identification of components that are important when considering the ability of farming systems to adapt to future climate change and variability. Additionally, this chapter has discussed an advanced FSAC framework (Figure 8.1) that contributes to our broad understanding about adaptive capacity, demonstrating that it can change over time. The advanced FSAC framework offers a novel contribution to both the farming systems and climate change adaptation literature. It not only identifies important contextually relevant components of adaptive capacity, but also highlights the interactions and potential trade-offs between them. Such findings about components, interactions and trade-offs have wider implications for understandings of adaptive capacity, which is often assessed as a static concept (Vincent, 2007, Adger and Vincent, 2005, Engle, 2011). These findings may also be relevant to the adaptive capacity of other SES, highlighting the broader relevance and implications of this thesis.

This thesis has also identified that farmers are not the only important actors making decisions that affect farming systems and adaptive capacity. Decisions made by NGOs and government policy makers are also important, as are the interactions between those decisions, highlighting potential to apply the FSAC framework to better understand the role of other influential actors. The application of the FSAC framework also provided invaluable insights into the various trade-offs undertaken by different actors. Policy-makers, including government officials and NGOs, must consider potential trade-offs when designing and implementing adaptation policies and programmes. Without consideration of trade-offs, maladaptation could occur (Suckall et al., 2014b).

This chapter also outlined a number of potential insights for adaptation planning at the sub-national and national level, and through this discussed the broader implications for adaptation planning. It suggested that the role of sub-national adaptation planning requires additional attention (Barrett, 2014) and that incentives may be needed to encourage national policy makers across SSA to better integrate adaptation into national level planning. Additionally, mainstreaming adaptation into existing and new policies provides a potential way forward in Uganda. However, before mainstreaming can occur, capacity building may be needed at both national and sub-national levels to better integrate adaptation into existing planning and policy cycles (Stringer et al., 2014). Finally, this chapter suggests that adaptation to future climate changes may require support for a range of response options to better enable local communities to adapt in their own ways.

Chapter 9 Conclusion

This chapter presents the general conclusions of this research and highlights priorities for future research.

9.1 General summary

This thesis set out to advance understanding about smallholder farming systems, adaptive capacity and adaptation in the context of climate change. The integration of historical and forward-looking analyses allowed for an exploration of the complexity and dynamic nature of smallholder farming systems, adaptive capacity and adaptation across space and time. It offers an empirical, conceptual and methodological contribution to the farming systems and climate change adaptation literatures.

This thesis used a mixed-methods multi-level approach to provide new empirical data about farming systems in eastern Uganda. Applying and advancing the FSAC framework enabled the identification of important factors that shape adaptive capacity and advanced our conceptual understanding of farming system adaptive capacity. The FSAC framework also lays a foundation for developing alternative approaches and interventions to strengthen the adaptive capacity of smallholder farming systems. It offers a conceptual and methodological contribution to understanding the dynamic, multi-level nature of farming systems and adaptive capacity and could be employed for other farming systems across SSA. In addition to this, the FSAC framework provides a structured way to think about complex systems across space and time and could therefore be adapted for adaptive capacity assessments of other SES. It could be applied in various geographical locations across SSA and beyond, and offers the potential to enhance adaptation decisions at the household, national, regional and international level.

Our understanding of farming system adaptive capacity has also been advanced by identifying trade-offs between different components of farming system adaptive capacity. Trade-offs result from decisions made by both policy-makers (policy-driven adaptation) and farmers (local-level adaptations). This thesis therefore builds on existing knowledge about the role of formal institutions in shaping adaptation, suggesting that there are overlaps between policy-driven and autonomous adaptations. This contributes to debates surrounding the definition and characterisation of autonomous adaptation, (Stringer et al.,

2009) and proposes that distinguishing between planned and autonomous adaptation is much less definitive in practice.

This thesis also offers new insights into adaptation planning. It supports calls for adaptation planning to be integrated into national level and sectoral policy making processes and for policies to foster inclusive institutions at the local level. As the wider literature demonstrates, failure to do so may result in fragmentation, conflict and inefficient policy and this increases the risk of policy-driven maladaptations. Moreover, this thesis highlights that technical solutions and optimal adaptation strategies alone are insufficient (Ericksen et al., 2009, Dessai et al., 2013). Instead, a broader focus on creating an institutional environment that supports a range of adaptation options is required. This makes an important contribution to the existing literature about the role of policy, and other formal institutions, in influencing adaptation.

Finally, this thesis supports calls for a critical rethink of the suitability of agricultural modernisation policies to support smallholder farming in the context of climate change and variability. One option is to explore alternative agricultural policies that are used in other countries across SSA, for example agro-ecological approaches or conservation agriculture in southern Africa (Andersson and D'Souza, 2014, Kremen et al., 2012). However, the universal applicability of silver bullet, technological solutions, is challenged by the diverse nature of smallholder farms and farming systems (Whitfield et al., in press). Rather than identifying technical or optimal solutions, this thesis provides evidence that fostering a range of options may better support farmers in adapting to future climate change and variability. At the farm level, Giller (2013) suggests that focussing on principles and processes may better support farmers to select from a basket of adaptation options. This could have the additional benefit of escaping the allure of silver bullet solutions (Giller et al., 2011). This thesis therefore contributes to enhancing agricultural policies and practices, which may necessitate coordinated actions to enhance synergies between actors operating at different levels.

9.2 Research priorities and opportunities

In addition to the valuable insights provided by this thesis, a number of research questions have been identified that warrant further investigation. This section highlights potential areas for future research, and in particular the potential for the methodology and FSAC framework to be applied to other SES and decision-making contexts.

1) This thesis has generated and integrated empirical data from different sources, methods and focussed on different levels and points in time. The innovative mixed-method, multi-level approach could be applied to other geographical areas in Uganda, for example to different agro-ecological zones, to generate additional empirical data about farming systems in Uganda and act as a further basis for comparative studies. Comparative studies would generate further insights into where broad policy support is needed in Uganda or when targeted, context specific interventions are required. The methodology could be further applied to understand smallholder farming systems across SSA. Such application could thus provide new empirical insights into our understanding of farming systems (Sumberg et al., 2013), which has not been updated since 2001 (Dixon et al., 2001).

2) Agricultural modernisation can shift the source of vulnerability, for example to dependence on commodity markets. This has implications for the ability of smallholder farmers and farming systems to adapt to future climate change and variability, and can be described as maladaptive. This is not reflected in the current conceptualisation of maladaptation proposed by Barnett and O'Neill (2010) and therefore highlights an area for future investigation. Research is needed to explore the factors that shift vulnerability rather than address it.

3) We need to better understand trade-offs between productivity, diversity and flexibility and how these influence short term and longer term adaptive capacity. Such research should also consider the role and decision-making processes of influential actors, within a farming system and beyond, and identify potential trade-offs. Additionally, more work is needed to determine how other political, economic, social and institutional factors enable or constrain flexibility, diversity and adaptation options. Without such understanding we run the risk of developing and implementing adaptation interventions that reduce adaptive capacity in the long term.

4) Critical approaches are needed to understand how policies can create an enabling environment to foster a range of future adaptation options. Furthermore, additional research is needed to identify the risks and benefits associated with enabling a range of adaptation options and how these may be distributed to create

winners and losers at different levels and at points in time. This would provide empirical evidence for potential synergies between adaptation and development.

5) Further work is needed to examine policy interplay between sectoral polices and how this shapes local-level adaptation options. Additionally, we need to better understand vertical and horizontal interplay between institutions and how they influence the range of adaptation options available at a local scale. This could provide further evidence that demonstrates how cross-scale institutional dynamics shape how resources are accessed and utilised. Analysing the policy interactions in other sectors and how they interact to influence local level institutions could foster inclusive local level formal and informal institutions that this thesis has identified as necessary for farming system adaptive capacity.

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Appendices

Appendix 1: Definition of key terms and concepts

Autonomous adaptation does not constitute a conscious response to climatic stimuli (Parry et al., 2007). Instead, it is an automatic, spontaneous or passive response to other changes, usually undertaken at the local level (Forsyth and Evans, 2013, Stringer et al., 2010).

Adaptation is "a process of deliberate change, often in response to, or anticipation of, multiple pressures and changes that affect people's lives" (Stringer et al. 2010: 146).

Adaptation planning informs the decisions about who should do what, when and with what resources that may result in a planned adaptation (Füssel, 2007).

Adaptive capacity is "the ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences" (Parry et al., 2007:869).

Climate change adaptation refers to "adjustments in natural or human systems in response to actual or expected climatic stimuli or their effects, undertaken in order to moderate harm or exploit beneficial opportunities" (Parry et al., 2007:869).

Climate hazards are natural physical events that may cause loss of life, injury, or other impacts, such as damage and loss to property, infrastructure, livelihoods, service provision, and environmental resources (IPCC, 2014c).

Farming systems approach developed from the 1970s, it has since been described as the beginning of a radical shift from top-down views of agricultural development towards a more holistic perspective (Cleary et al., 2001).

General resilience refers to resilience of any and/or all parts of a system to all kinds of shocks and stresses (Folke et al., 2010).

Individual farm system refers to a household, its resources, and the resource flows and interactions at the individual farm level (Dixon et al., 2001).

Institutions are the formal and informal rules, norms and beliefs that govern behaviour and shape how individuals and organisations act and interact (Ostrom, 1990, Scott, 2001).

Maladaptation any response that is not sustainable (Vincent et al., 2013)

Path dependency occurs when a particular policy or technology becomes dominant, self-reinforcing, and can potentially exclude superior solutions (Chhetri et al., 2012)

Planned adaptations are deliberate policy decisions and activities that explicitly consider climate changes, such as when designing infrastructure or developing agricultural technologies (Forsyth and Evans, 2013).

Social–ecological systems refer to complex systems where humans and nature are interconnected and interdependent (Folke et al, 2010).

Specified Resilience is the resilience of something, to something; resilience of some particular part of a system, to one or more identified kinds of hazard (Folke et al, 2010).

Vulnerability in natural hazards studies is the susceptibility to be harmed (Adger, 2006a). In the climate change literature, vulnerability is a function of exposure, sensitivity and adaptive capacity (IPCC, 2013a).

Appendix 2: Ethical Clearance and Risk Assessment

Ethical Approval letter

Research Support
3 Cavendish Road
University of Leeds
Leeds LS2 9JT

Tel: 0113 343 4873
E-mail: j.m.blaikie@adm.leeds.ac.uk

UNIVERSITY OF LEEDS

Jami Dixon
Room 9.157
Sustainability Research Institute/
Institute for Climate and Atmospheric Science
School of Earth and Environment
University of Leeds
Leeds, LS2 9JT

AREA Faculty Research Ethics Committee
University of Leeds

Dear Jami

Title of study: **Integrating approaches to assessing climate impacts in Uganda: can it enhance adaptation policy and practice**
Ethics reference: **AREA 11-059**

I am pleased to inform you that the above research application has been reviewed by the ESSL, Environment and LUBS (AREA) Faculty Research Ethics Committee and I can confirm a favourable ethical opinion as of the date of this letter. The following documentation was considered:

Document	*Version*	*Date*
AREA 11-059 DIXON_ethical_approval_sept11.pdf	1	20/09/11
AREA 11-059 DIXON_policymaker_information_sheet.pdf	1	20/09/11
AREA 11-059 DIXON_participant_information_sheet.pdf	1	20/09/11
AREA 11-059 DIXON_Model_Participant_Consent_Form.pdf	1	20/09/11

Please notify the committee if you intend to make any amendments to the original research as submitted at date of this approval. This includes recruitment methodology and all changes must be ethically approved prior to implementation.

The reviewers made the following suggestion:

- The ethical and methodological challenges of using interpreters are well discussed in the literature. It would be well worth familiarising yourself with the potential problems, e.g. the tendency of interpreters to alter what you are saying, or the way in which the use of interpreters affects the positionality of the researcher, and their relationship with the participants. Whilst this may not change how you plan to do things, it might give you a better idea of how to deal with any problems or issues that emerge during research

Please note: You are expected to keep a record of all your approved documentation, as well as documents such as sample consent forms, and other documents relating to the study. This should be kept in your study file, which should be readily available for audit purposes. You will be given a two week notice period if your project is to be audited.
Yours sincerely

Jennifer Blaikie
Research Ethics Administrator, Research Support
On behalf of Dr Anthea Hucklesby
Chair, AREA Faculty Research Ethics Committee

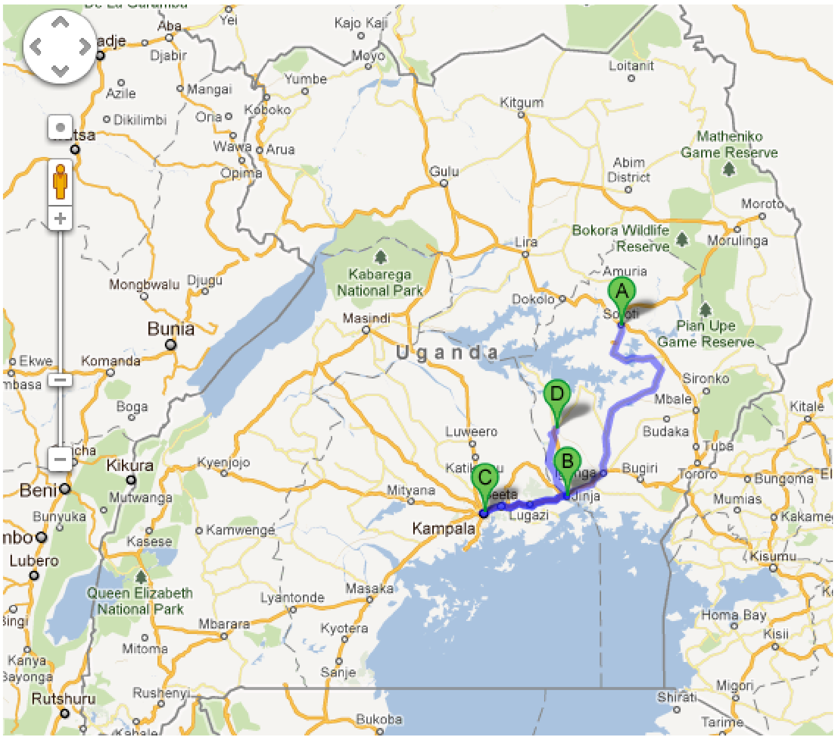
CC: Student's supervisor(s)

Fieldwork Risk Assessment (High Risk Activities)

Fieldwork Project Details	
Faculty School/Service	JAMI DIXON
Location of Fieldwork	UGANDA
Brief description of Fieldwork activity and purpose *(include address, area, grid reference and map where applicable)*	**December 2011 – September 2012** The trip is the main fieldwork and data collection period due to begin in January 2012 for a period of 8 months. The Fieldwork will involve spending time split between rural and urban areas of Kampala, Jinja, Soroti and Kamuli undertaking the following activities: site visits to rural areas (Kamuli and Soroti); collecting survey data in rural areas; facilitating focus group discussions in rural areas; visiting archive and departments to collect secondary data; meetings and interviews with community leaders and key informants in rural areas; discussions and meetings with various stakeholders in Kampala. I lived in Uganda for 2 years only from 2008-2010. I have also spent 3 month in Uganda this year prior to this main data collection period. As a result I am familiar with the environment and have a range of contacts who are willing to support me. I have spent a considerable amount of time travelling within the country and working with people from a range of cultural backgrounds. I also have an existing support network in Uganda where some accommodation has been pre arranged. I have spent time or at least visited in all of the areas where I intend to conduct the research. I will use accommodation in Jinja Town as a main base, but will stay in Kamuli, Kampala and Soroti towns when necessary to avoid lengthy driving times and driving at night. Known addresses for accommodation whilst in these places are provided below. I will use hotels in these urban in the short term, but may make some longer term arrangements in Soroti (200km from base in Jinja). I will communicate information to my Supervisors. The activities listed above will require some field visits and may involve overnight stays in rural areas, however every effort will be made to return to accommodation in urban areas of Kampala, Jinja or Soroti. When this is not possible I will stay in the village and either camp using my own tent and equipment or stay in a local accommodation approved by the village chairperson. When I travel to rural locations I will take a research assistant

with me who knows the area, ensuring that I will never travel alone. When I am based outside of urban areas I will have a research assistant/translator with me at all times. I will phone ahead to contacts based near or in these rural areas to ensure travel is safe and if there is any indication of trouble or the potential for problems then I will make alternative plans. I will leave details of my trips and contact details with Miss Sharon Webb, a friend based in Jinja (contact details below) who I will check in with daily. I have been added to a caller user group in Uganda which provides free calls within the network, meaning I will always be able to make a phonecall even if I am unable to top up credit.

Map of Uganda
A= Soroti
B = Jinja
C= Kampala
D= Kamuli



	Longitude	Latitude
Soroti	33°35'E	1°43'N
Jinja	33°12'E	00°25'N
Kampala	32°30'E	00°20'N
Kamuli	33°04 E	01°11'N

Existing Contacts:

Kampala:

Makerere University, Kamala
Dr Moses Tenywa, Director Makerere University Agricultural Research Institutue
Makerere University, P. O. Box 7062, Kampala, Uganda
Tel: +256-772-827710
Alternative Tel: +256-414-542277

Soroti:

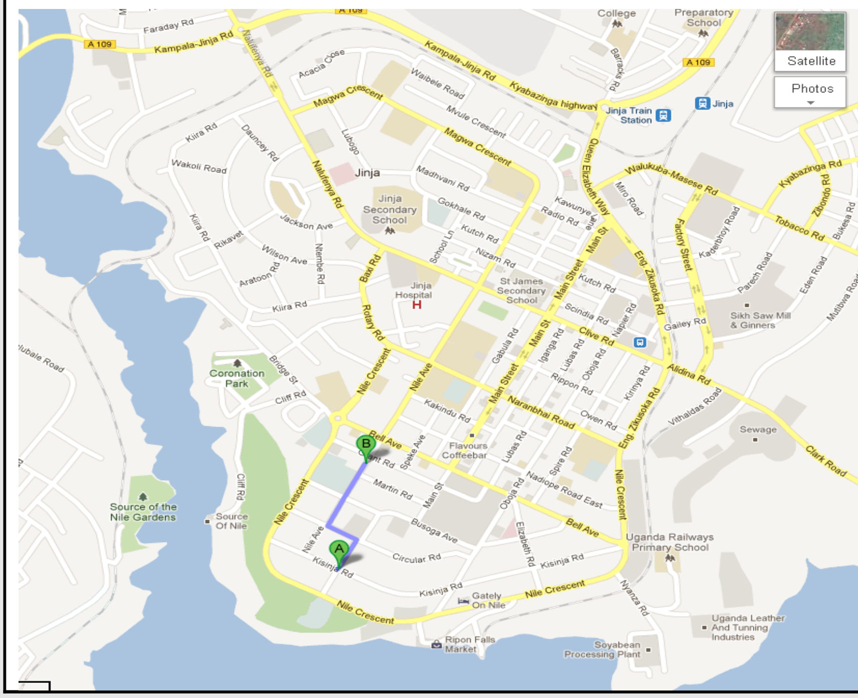
Local Government
Emaju Charles Francis, District Agricultural Officer.
Phone: 0772580701
Email: cemaju@yahoo.com

Jinja:

Soft Power Education
Sharon Webb, Plot 6 Kyagwe Avenue, PO BOX 1493, Jinja, Uganda
Tel no. +256772903344
marked 'A' on the map below

Address in Jinja:

Plot 17A Nile Avenue,
Jinja,
Uganda
Marked 'B' on map below



Fieldwork itinerary
e.g. flight details, hotel address

Flight Details

Arrive 30th December 2011 – 14th September 2012

Outbound:

Flight : London – Entebbe 30/12/2011

From:	NEWCASTLE	**To:**	HEATHROW,

Depart:	Friday, 30/12/2011 7:45	**Arrive:**	Friday, 30/12/2011 9:00
Airline:	British Airways		
Flight:	BA 063		
Class:	N-Economy		

Flight : London - Entebbe 30/12/2011			
From:	HEATHROW, Terminal 5	**To:**	ENTEBBE INTERNATIONAL
Depart:	Friday, 30/12/2011 10:45	**Arrive:**	Friday, 30/12/2011 22:10
Airline:	British Airways		
Flight:	BA 063		
Class:	N-Economy		

Inbound

Flight : London - Entebbe 30/12/2011			
From:	ENTEBBE INTERNATIONAL	**To:**	HEATHROW, Terminal 5
Depart:	Friday, 14/09/2012 09:10	**Arrive:**	Friday, 14/09/2012 15:55
Airline:	British Airways		
Flight:	BA 062		
Class:	Q-Economy		

Flight : London - Entebbe 30/12/2011			
From:	HEATHROW, Terminal 5	**To:**	NEWCASTLE
		Arrive:	Friday, 14/09/2012 19:30
Depart:	Friday, 14/09/2012 18:20		
Airline:	British Airways		
Flight:	BA 1336		
Class:	N-Economy		

Overview of Field Plans

January – based in Jinja but **with visits to Soroti & Kamuli to make fieldwork arrangements**

February – based in Jinja, but travelling to Kamuli for data collection

	March - based in Jinja, but travelling to Kamuli & Soroti for data collection **April –** based in Soroti for data collection **May -** based in Jinja, but field visits to Kamuli/Soroti may be required **June -** based in Jinja, but travelling to Kamuli & Soroti for data collection **July -** based in Jinja, but travelling to Kamuli & Soroti for data collection **August -** based in Jinja, but travelling to Kamuli & Soroti for data collection **September -** based in Jinja, but field visits to Kampala/Kamuli/Soroti may be required **All months -** potential visits to Kampala to attend Makerere University, find secondary data and/or hold interviews with stakeholders.
Organiser Details	**Contact details** *Name, Email, Telephone*
Fieldwork Activity Organiser / Course Leader	Name: Jami Dixon Email: jhm3jld@leeds.ac.uk Uganda tel no: +256779351155 Supervisors: Dr Lindsay Stringer & Prof Andy Challinor
Departmental Co-ordinator	H&S: David Banks
Nature of visit *Size of Group, lone working, staff, postgraduate, undergraduate*	Research postgraduate Scoping Study
Participant Details *Attach information as separate list if required*	**Contact details** *Name, Address, email, telephone, Next of Kin contact details*
	Jami Dixon, Address: 1 Silverdale, Sunderland, SR3 2TS UK Tel no: (+44) 07599375775 Uganda Tel no: (+256) 0779351155 Email: jhm3jld@leeds.ac.uk Next of kin: Neville Dixon, Address: 1 Silverdale, Sunderland, SR3 2TS Tel no: (+44) 07931544992 Email: nev_d@msn.com

HAZARD IDENTICATION

Identify all hazards specific to fieldwork trip and activities, describe existing control measures and identify any further measures required.

HAZARD(S) IDENTIFIED	CONTROL MEASURES *(e.g. alternative work methods, training, supervision, protective equipment)*
Nature of the site *School, college, university, remote area, laboratory, office, workshop, construction site, farm, etc* Staying in Urban centres with travel to rural village sites required. The main base will be in Jinja, which is has an International Medical Centre, but is also only 80kms from Kampala where more specialised Medical centres are available, for example International Hospital Kampala (address provided). All other potential sites are listed below with their distance (in kilometres) from Kampala. All Districts have basic medical facilities, in case of emergency. None of the areas are more than 400km from Kampala and are therefore within a reasonable distance, no more than 6 hours by road. Distance from Kampala by road (kms) Entebbe (Airport) 37 Jinja 80 Soroti 280 Kamuli 110	Kampala Hospital: International Hospital Kampala (IHK)] Plot 4686 Kisugu - Namuwongo P.O.Box 8177 Kampala - Uganda **Tel:** +256 41 200444 or +256 31 2200400 **E-Mail: ihk@img.co.ug** Emergency Services: Police -Parliamentary Avenue, Kampala, Uganda 999/112 SMS crime Network:999 +256-41-234920 website: http://www.upf.go.ug Fire Brigade: 0414342222/3 Address and telephone number of the nearest British Embassy British High Commission, 4 Windsor Loop, PO BOX 7070 Tel : +2567552787777 Personal Contact Information: Mobile phone, Email & Skype. A weekly Email will be sent to both PhD supervisors to notify them of any changes and to update them with progress. Monthly skype chats have also been organised . If the supervisors are unable to make contact then alternative contact numbers are provided: Contact in Uganda Friend, Sharon Webb, +256774162451 Soft Power Education, Hannah Small, +256772903344
Environmental conditions *Extremes of temperature, altitude, exposure to sunlight, potential weather conditions, tidal condition etc*	✓ Allow at least a day for acclimatisation & to recover from flight ✓ Avoid exposing unprotected skin.

Most of Uganda is at a fairly constant altitude. The majority of the country is tropical, with temperatures averaging about 26C during the days and 16c at night. The hottest months are December to February with temperatures up to 30c. The highlands can be considerably cooler at night. Rainy seasons are generally from April to May and October to November. Potential for sunstroke & sun related injuries, e.g. dehydration Some wild and domestic animals such as streets dogs, venomous snakes and insects.		✓ Use suitable sun block during the day. ✓ Drink plenty of water to avoid dehydration. ✓ Only drink bottled, boiled or treated water ✓ Carry and use hand sanitiser ✓ Only eat cooked food. ✓ Seek medical advice before travel. ✓ Have booster injections before travel ✓ Take a malarial prophylactic. ✓ Pay attention to weather forecasts to ensure prepared for weather conditions ✓ Be aware of surroundings ✓ Make sure I know how to recognise and treat bites/stings and/or be accompanied by someone who does. ✓ Avoid long grass ✓ Make plenty of noise ✓ Check where you place your feet ✓ Always carry a first aid kit and mobile phone
Site specific conditions *e.g. cliffs, screes, bogs, featureless landscapes, local endemic infectious diseases, zoonoses etc*		✓ Check FCO website before departure to check for any travel updates or advice ✓ Register on FCO website before departure ✓ Be aware of local and cultural sensitivities ✓ Seek medical advice before travel to find out what inoculations are necessary ✓ Have booster injections and ensure inoculations are up to date before travel ✓ Take a malarial prophylactic ✓ Cover up wearing long trousers and tops in the evening to minimise risk of insect bites ✓ Use DEET to deter mosquitoes ✓ Exercise caution when crossing roads paying attention to traffic ✓ Avoid swimming and bathing in water sources ✓ Where appropriate footwear (always wear socks) ✓ Always be accompanied by a translator when on remote village sites ✓ Exercise caution when moving around ✓ Use only approved pathways etc when available
Checked on FCO website for country updates and travel advice for British Citizens. They advise the potential for political instability, recent elections and potentially hostile local people. Inner City - Traffic. Infectious diseases **Schistosomiasis** (also known as bilharzia, bilharziosis or snail fever) is a parasitic disease found in water. **Malaria** – infectious disease carried by female mosquitos **HIV** – current rate around 6% - Uganda is one of the few African countries where rates of HIV infection have declined Remote Village visits: Uneven terrain, slippery surfaces, hidden objects protruding from		

ground, poor sanitation, mosquitos.		✓ Only eat cooked that I have prepared or that has been prepared in an established eatery ✓ Wash hands & use hand sanitizer before eating
Process *Operating machinery, electrical equipment, driving vehicles, handling or working with animals et* Interviewing or meeting with groups or individuals.		✓ Phone ahead to ensure that destination is safe to travel to ✓ Avoid one to one interviewing situations –have a research assistant or translator present ✓ Hold meetings / interviews in open & safe public places where possible ✓ Always inform someone of whereabouts and an ETA (Sharon Webb)
Transport *Mode of transport while on site, to and from site, carriage of dangerous goods etc* Public transport may be used to travel between meetings, places and sites. A private vehicle will be purchased by the researcher and checked over and maintained by an international mechanic. The researcher will do most of the driving, though a driver may be necessary at times. If this vehicle breaks down a vehicle may be hired to conduct field visits. No dangerous goods will be carried.		✓ Use reliable methods of transport. ✓ Where possible minimise travelling alone and take care when unavoidable. ✓ Travel by road only in daylight hours. ✓ Do not embark on any journey without advising anyone of planned route and ETA. ✓ Use only certified vehicles & drivers ✓ Ensure vehicle is insured ✓ When travelling to rural locations ensure accompanied by someone who knows the local area ✓ Researcher has a valid Ugandan driving licence and 3 years experience driving in Uganda
Equipment *manual handling risks, operation of machinery, tools, use of specialist equipment etc* No specialist equipment is needed as no machinery will be operated. A laptop will be taken to ensure that frequent contact is possible.		✓ Take first aid kit & wear site specific clothing ✓ Wear appropriate footwear ✓ Ensure laptop is ensured

Violence *potential for violence (previous incidents etc)*		✓ Refer and follow FCO advice. ✓ Minimise exposure to confrontational issues. ✓ Avoid political rallies and demonstrations ✓ Avoid moving alone at night ✓ Avoid carrying valuable goods ✓ Avoid **places frequented by expatriates and foreign traveller**s ✓ Ensure adequate travel insurance is sought before departure – organised through University of Leeds ✓ Read newspaper daily to keep up to date with current affairs in the country ✓ Try to phone ahead to someone either based in or near to the intended site visit town or village ✓ Talk to people about the current situation in the country & potential for unrest
FCO advice – high threat from terrorism: 11 July 2010 bomb attacks in Kampala left over 70 people dead and significant numbers injured. The al-Shabaab leadership has claimed responsibility and have threatened further attacks in the region Chance of violent crime, such as mugging, in urban areas. Elections held in February/March – relatively peaceful, but risk of subsequent local unrest such as political demonstrations		
Individual(s) *medical condition(s), young, inexperienced, disabilities etc*		✓ Any medical issues arising will be reported to Supervisors at the first opportunity ✓ Adopt cautious approach at all times and use common sense. ✓ Supervisors will check & approve the risk assessment before travel & a copy will be left with them
There are no existing medical conditions. Researcher has prior experience of independent travel and research in Uganda. In addition to this she has also lived in both a rural and urban setting in Uganda, meaning that she is well versed with cultural issues and sensitivities.		
Work Pattern *time and location e.g. shift work, work at night*		✓ Undertake activities in day light hours, between 7am & 7pm. ✓ Plan ahead to leave plenty of time for travelling ✓ Avoid travelling at night ✓ Drink and carry plenty of water ✓ Sleep for minimum 8 hours to prevent exhaustion ✓ Avoid midday sun
Given the nature of the planned activities they should be completed within normal hours of work.		

Permissions Required *Contact details, restrictions and details of permissions* Current visa covers fieldwork activities as no paid work is being undertaken in Uganda. This visa is valid until 8th July. To visit and access some of the national archives or gather existing data, permission may be required. Site visits outside Kampala will be required which may require permission to be obtained locally		✓ Check visa is valid ✓ Use Personal Ugandan Driving Licence as proof of Identity ✓ Ensure appropriate permission is sought before trying to access places or data ✓ Contact has already been made with Dr M Tenywa, at Makerere University who has advised that local permissions can be sought when in the country ✓ Research clearance from Uganda National Council for Science and Technology (UNCST) has been obtained. ✓ Obtain permission locally by making contact with local political, cultural & religious leaders ✓ Ensure appropriate permission is sought prior or at the earliest opportunity for specific site visits
Other Specific Risk Assessments *E.g. COSHH, Manual Handling, Lone Working if so what is identified in these assessments? Are there training requirements? (cross reference where appropriate)* Fieldwork will not involve any COSHH or Manual handling activities.		N/A
Health Questionnaire Completed *Is it required and has it been completed, who by and where is it recorded*		✓ No matters arising from Health - a copy of the form & full risk assessment will be left with supervisors. ✓ Filled in form for Leeds Student Medical Practice to get appropriate advice.
Health Surveillance Required *Is it required and has it been completed, who by and recorded*		N/A
Vaccinations Required *Obtained and certificate where applicable* Yellow Fever, Meningitis, Hepatitis, Tetanus		✓ Checked with Leeds Student Medical Practice that all vaccinations are up to date and no additional vaccinations or boosters required ✓ Carry Yellow Fever certificate ✓ Take malaria prophylaxis
First Aid Provision *Requirement for first aid or specialist first aid equipment, access to medical equipment and hospitals* Completed 2 basic first aid courses, I currently hold valid 'emergency life support' and		✓ Take a comprehensive first aid kit as recommended by the Health and Safety Executive ✓ Carry first aid kit at all times

‘first aid at work’ certificates.		

Additional Supporting Information		
Pre-departure Briefing *Carried out and attended*		✓ Organise a pre departure meeting with supervisors one week before leaving ✓ Check insurance ✓ Check field plans ✓ Swap contact details
Training *Identify level and extent of information; instruction and training required consider experience of workers, details of relevant training* No additional training is needed for this trip.		✓ The Researcher attended ‘Fieldwork Risk Assessment Workshop’ on 18th February ✓ In 2008 Researcher conducted large scale social survey in a rural setting in Uganda ✓ Researcher has adequate experience holding meetings and interviews. ✓ In addition to this Researcher lived in Uganda for 2 years.
FCO advice *Include current FCO advice for travel to the area where applicable*		FCO website: Uganda *“This advice has been reviewed and reissued with amendments to the Travel Summary, and the Safety and Security - Political Situation and Safety and Security - Terrorism sections (elections). We advise against all travel to Karamoja region except for trips to Kidepo Valley National Park.* **High threat from terrorism. Attacks could be indiscriminate, including in places frequented by expatriates and foreign travellers”.** *http://www.fco.gov.uk/en/travel-and-living-abroad/travel-advice-by-country/sub-saharan-africa/uganda*
Supervision *Identify level of supervision required e.g. full time, Periodic telephone/radio contact* Weekly updates with supervisors via Email		✓ Supervisors to approve risk assessment ✓ Send weekly Email to supervisors ✓ Organise monthly skype chats ✓ Use mobile telephone numbers in case of emergency
Other Controls *e.g. background checks for site visits, embassy registration* Ensure that British Embassy know whereabouts in case of an emergency		✓ Register with British Embassy in Uganda using ‘Locate’ scheme for travellers http://www.fco.gov.uk/en/travel-and-living-abroad/staying-safe/Locate/

Identify Persons at Risk *This may include more individuals than the fieldwork participants e.g. other employees of partner organisations* *Copy of other Organisation's risk assessment attached?* N/A	N/A
Additional Information *Relevant to the one working activity including existing control measures; information instruction and training received, supervision, security, increased lighting, emergency procedures, access to potable water etc.*	✓ Report all accidents, incidents and cases of ill-health to Health and Safety Services through the Sentinel accident reporting system and to Health and Safety Co-ordinator where appropriate ✓ Appropriate clothing & footwear will be worn: walking boots; Rain coat & trousers; Cold weather clothing if necessary ✓ In case of emergency contact Supervisors and/or Health & Safety Coordinator ✓ When more information is known about the field visits outside urban areas or if plans change then Email Supervisors & Health & Safety Coordinator with details

Residual Risk *Is the residual risk acceptable with the identified controls?*	Yes	
	Yes	

Assessment carried out by	Name:	Jami Dixon
	Signature:	J Dixon
	Date:	15th December 2011
Names of person(s) involved in Fieldwork *N.B: This can take the form of a signed class register when large group work*	Name:	Jami Dixon
	Signature:	J Dixon
	Date:	15th December 2011
Fieldwork Activity	Name:	Dr Lindsay Stringer

Organiser / Course Leader *e.g. PI, etc*	Signature:	
	Date:	15th December 2011

Appendix 3: Phase I Methods

Household Survey

Part 1.Basic Information					
Personal Information			**Contact Telephone Number**		
1.1 ID CODE	1.2 Sex (Male /Female)	1.3 Age	1.4 Main source of Income	1.5 Which tribe do you belong to?	1.6 Place of birth (District)
1.7 What is your marital status?	1.8 No of people in your Household?	1.9 How many biological children do you have?	1.10 How many wives do you have/does your husband have?	1.10 Are you a member of any groups (if yes what)	1.12 Highest Level of education reached ?
1.13 Taken part in programmes run by government or other organizations? (If yes with who & what programme)			1.14 What type of House do you have?	1.15 How many rooms are there in your house?	1.16 Do you have power at your home?

1.17 Household Information				
First Name	Age	Sex	Relationship to respondent	Do they provide labour/dig/ help in your garden?

1.18 How many meals do you have on an average day?	

1.19 Is there anyone in the household unable to dig due to health problems? (If yes please give details)

Part 2. Farming System & Livelihood Survey

Financial Assets

2.1 What are your main sources of household income in the last year?	tick those that apply		
Fishing		Livestock	
Making charcoal		Casual Work	
Commerical Farming (crops)		Own Business - self employed	
Subsistence Farming (crops)			
Tourism			
Other (Please state) ………………………………			

2.2 Have you ever had a loan from (tick those that apply)	
a) friends/ neighbours	
b) family/relatives	
c) Microfinance	
d) Bank	
e) Other organisations	
f) Government	
g) never had a loan	

2.3 Do you have a loan?	Yes	No	
2.4 Are you a member of a savings or credit scheme?	Yes	No	2.4a If yes with who
2.5 Do you have a bank account?	Yes	No	

2.6 Do you own a ….					
a) car	Yes	No	d) radio	Yes	No
b) motorbike	Yes	No	e) TV	Yes	No
c) bicycle	Yes	No	f) Mobile	Yes	No

Productive Assets

2.7 Do you have an apiary/bee keeping?			Yes	No	
2.8 Do you grow crops?	Yes	► Go to 2.9			
	No	► Go to 2.28			
2.9 What type of land do you grow your crops on?		Own land	rented land	Com. land	O
2.10 Do you have the land/legal title	Yes	No	Not sure		
2.11 How many acres is your land?		acre s			

We would like some detailed information on the crops that you planted last season, tick if you use them for (eating) food, or cash, or both food and cash. Leave blank if you do not grow

2.12 Food Crops		2.13 Other crops

Crop	Food	Cash
Beans		
Cabbage		
Carrots		
Cassava		
Egg plant		
G nuts		
Green Pepper		
Greens - Dodoo		
Irish Potatoes		
Maize		
Matooke		
Millet		
Onions		
Peas		
Pumpkins		
Sim sim		
Sorghum		
Soya beans		
Sweet Pots		
Tomatoes		
Yams		

Crop	Food	Cash
Avocado		
coffee		
Cotton		
Crops for biofuel		
Jack fruit		
Jatropha		
Lemons		
Mango		
Oranges		
Passion fruit		
Paw paw		
Pineapple		
Rice		
Sugar cane		
Sunflowers		
Sweet bananas		
Tobacco		
Vanilla		
Other crops (please list below)		

2.14 Where do you sell your produce?

(if they do not sell ► Go to 2.19)

2.15 if markets which market(s) do you sell at? Please give the names.

2.16 How many Kilometers to the market? (please circle)

less than 1 km	more than 1 but less than 2	over 2 but less than 4	over 4 but less than 8	over 8kms less than 16	more than 16 kms

2.17 How many minutes does it take you to reach the market? (please circle)

____

less than 30 minutes	more than 30 minutes but less than 60 (1 hour)	more than 60 minutes but less than 90 (1.5 hours)	more than 90 minutes but less than 120 (2 hours)	more than 120 minutes but less than 150 minutes (2.5 hours)	more than 150 minutes but less than 180 (3 hours)	More than 3 hours

2.18 How do you transport things to market? (please circle)

private vehicle	matatu / taxi	walk / by foot	bicycle / boda boda	shared transport	Other (Please state) …………….. …….	

2.19 Have you ever received any agriculture training?

Yes	No	If No ► Go to 2.20

2.19a if yes can you tell us about it

2.20 Which crops grow well in your soil?

2.21 Which crops don't grow well in your soil?

2.22Can you describe your soil / What type of soil do you have?

2.23 Who works on the land? (please circle all that apply)	Men	Wom en	Children	Hired Labour	O.

2.24 What do you think are the most important factors in affecting crop yields on your land?

2.25 Do you use pesticides on your crops?			Yes	No	not sure	
2.25a if yes, which ones						
2.26 Do you use any fertlisers on your crops?			Yes	No	not sure	
2.26a if yes, which ones						
2.27 Do you use any other inputs on your crops?			Yes	No	not sure	
2.27a if yes, which ones						

2.28 Do you own any livestock?	yes	► Go to 2.29
	no	► Go to 2.34

2.29 What Livestock do you own?	Tick	No.
Goats /sheep		
Chickens		
Cows		
Pigs		
Guinea Fowl		
Oxen		
Other …………………..		

2.30 Where do the animals stay?	own land	com muni ty land	family land	other please state ……………… …... ……………… ……………..
2.31 Do you ever graze your animals on community land?	Alway s	som etim es	never	

2.32 Who looks after the animals? (please circle all that apply)	Men	Women	Children	Hired Labour	Other

2.33 Have you ever received any livestock management/animal husbandry training?	Yes	No	► If no go to 2.31

2.33a if yes can you tell us the type of training, who provided it and when

2.34 Do you catch fish?	Always	sometimes	never	► If never go to 2.37
2.35 Do you eat the fish you catch?	Always	sometimes	never	
2.36 Do you sell the fish you catch?	Always	sometimes	never	

2.37 Do you sell firewood/charcoal?		Yes	No

Other Assets

2.38 What is the nearest water source you use to get water for household use, e.g drinking water?

borehole/ well	tap	river / spring	water tank	other

2.39 How far is the nearest water source you use to get water for household use?

less than half a km	over 0.5 but less than 1	over 1 but less than 2	over 2 but less than 4	more than 4 kms

2.40 How often do you leave your compound to get water for household use?

once a day	more than once a day	2-3 times a week	once a week	less than once per week	Rarely	Never

2.41 How many minutes does it take you each time to get water for household use?

less than 30 minutes	more than 30 minutes but less than 60 (1 hour)	more than 60 minutes but less than 90 (1.5 hours)	more than 90 minutes but less than 120 (2 hours)	more than 120 minutes but less than 150 minutes (2.5 hours)	more than 150 minutes but less than 180 (3 hours)	More than 3 hours

2.42 How many kilometers to the nearest tarmac road?

less than 1 km	more than 1 but less than 2	over 2 but less than 4	over 4 but less than 8	over 8kms less than 16	more than 16 kms

Additional Comments

Part 3. The Past

3.1 How many years have you lived in this village?

3.2 Have you lived in any other villages in this District?

Yes	No

3.2 a if yes which ones and for how long?

3.3 Have you lived in any other Districts?

Yes	No

3.3a if yes which ones and for how long?

3.4 Which years can you remember being difficult or bad years for people living in this village?

3.5 Why do you think they were difficult or bad years?

3.6 Which years have been the best for agriculture in your memory?

3.7 Why do you think they were good years for agriculture?

3.8 What positive changes have you noticed in this village since you have lived here?

3.9 What negative changes have you noticed in this village since you have lived here?

3.10 Have you noticed any changes in the natural environment?

Yes	No

3.10a If yes can you describe them

3.11 Can you tell me about weather in this village over the last 50 years / since you have lived here?

3.12 Have you experienced any droughts?

Yes	No

3.12a If yes can you tell me about them - for example when did they occur, how did they affect people in the village

3.13 Can you tell me the meaning of the word drought

3.14 Have you experienced any floods?

Yes	No

3.14a If yes can you tell me about them - for example when did they occur, how did they affect people in the village

3.15 Can you tell me the meaning of the

word flood

3.16 Do you have any ways of predicting or knowing what the weather is going to be like?	Yes	No

3.16a if yes can you tell me about them

END!
Thank you for your time

Focus group discussion Protocols	
Ethics Checklist Read out at the beginning of each focus group	✓ Explain what the results will be used for PhD ✓ Information will be seen by others inside and outside of Uganda – but participants will remain anonymous (no names) ✓ Confidentiality will be respected – no names will be used when reporting findings ✓ Data will be stored safely and securely – under password protection ✓ If you are unsure of the question or don't want to answer then that is ok ✓ You should feel free to have breaks when you need ✓ There is an option to withdraw at any time – you will not be forced to take part ✓ We will report data fairly and accurately ✓ We will come back to Uganda to share result and Initial findings will be reported and presented in Uganda – a copy of a report will be given to the District, subcounty and village. ✓ We will be respectful, open and honest at all times ✓ Mobile phones to be switched off or on silent during sessions
A) **Intro.** **(1 in each village)**	**Objectives of focus group** - To introduce this research and the research team and answer any questions you may have about this research - To obtain consent to work in this village - To list indicators of wealth in this village - To recruit members for future focus groups - To draw up a community resource map of the village **Key Questions** - What are the main livelihood activities in the village? - About how many people are involved with each different activity. - What do men mainly do? Is this different for women?

Focus group discussion Protocols	
B) **Livelihood analysis and current issues** **(1 in each village)**	**Objectives of focus group** - To establish what issues people are currently experiencing with their livelihoods - To rank issues in order of significance - To produce a causal diagram of current issues and discuss causal relationships - To identify root causes of current livelihood problems **Key Questions:** - What issues are people facing in their day to day activities?" - (personal, institutional, political, cultural, socioeconomic, demographic, environmental etc) - Which ones of these are the biggest? - What crops grow well here – why? Is there a consensus? - What crops don't grow well – why? Is there a consensus? - Any crops grown in the past that aren't grown today? Vice versa - We have discussed low yields, but are there any other issues which cause more problems. **Pairwise ranking** 1. List problems vertically and horizontally so the same problem appears at the same position on the vertical and horizontal axis. 2. Compare problem one with problem two and note the number of the most important issue in the corresponding box 3. Repeat this process until all issues have been compared and each box has a number in it. Count the number of times each problem occurs in the boxes to come up with rankings. 4. Are livelihood challenges the same for everyone? (e.g different for men and woman? Older people / younger people?) **Causal Diagram** 1. Explain that we are now going to examine the problem of low yields 2. Ask what are the factors affecting crop yield – make a list of all of the factors, give each factor a symbol. Write these on chalk board and score them in order of importance 3. Explain that often problems are connected and the next step is to look at the connections between the problems identified. This can be explained briefly using an

Focus group discussion Protocols	

C) **Past Events and Coping**
 	
(1 in each village)
	Objectives of focus group
	
	- To identify what people think were the best and worst years for agriculture and explore reasons for this
	- To understand significant (including weather) events people have experienced over the past 50 years (since 1960s) and how people responded
	- To identify drivers of and barriers to coping/adapting in the case of these past events
	
	Timeline building
	
	1. What is the earliest event in this village that anyone can remember? Discuss how this affected the village?
	2. What events do you remember as affecting people in this village since 1960 / things that have happened in the last 50 years.
	3. What events can people remember happening in the 1960s/70s/80s etc?
	4. Continue from 1960s to present to build timeline – ask about any weather events.
	5. How did people respond to these events? What did they do to survive?
	6. How did they affect the village? Positive affects or negative effects?
	7. Did it affect everyone in the same way? (noting down any explanations and reasons given)
	8. Since 1960s, what have been the best and worst years for agriculture?
	9. Why? What are the main reasons.
	10. Discuss – any discrepancies or conflicting information
	
	Key Questions:
	
	- Out of all of these events in last 50 years, which one(ones) do you think has had most impact on how things are in the village today and why?
	    - How did people cope?
	    - How effective were the coping strategies? – barriers to coping effectively – reasons for coping effectively
	    - What other factors contributed to the problems that people were experiencing?

Focus group discussion Protocols	
D) **Weather, climate and agriculture** **(1 in each village)**	**Objectives of Focus Group** - **Produce rainfall calendars for a normal year** - **Produce rainfall calendars for 2010 and 2011** - **Compare rainfall in agriculture between 201/2011/normal year** **Rainfall Calendars** 1. Agree symbols for : (symbol table below) 2. We need to agree in a normal year, how you expect the rains to be and what you expect the temperatures to be like 3. . We will go through each month using the agreed symbols to discuss how much rain you expect in each month, then we will shade on rainfall calendar 4. We will then go through each year (2011 and 2010) month by month and discuss rainfall and temperature. We will use symbols to describe the rainfall/temp in each month 5. We will need to reach a consensus for this – if you don't agree then please say so and we can discuss **Key Questions:** - Can you describe agriculture in a normal year? - What do you normally grow in the first season? why? - What do you normally grow in the second season? - What did you grow in 2010/2011? - Was it the same as normal? Why / why not? - How would you describe the rains in 2010 / 2011? - How would you describe farming in 2010 / 2011? How did it compare with a normal year?

Light rain		**No rain**		**Normal rain**		**Heavy rain**	
Normal temp		**High temp**		**Cold temp**		**Very cold temp**	

Semi-structured interview protocol for farmers

Topics for discussion

- Agriculture, weather and rural livelihoods
- Past events, change and coping
- Policy
- Uganda in 2030s

1. **Can you tell me a little bit about yourself?**
   - Place of birth
   - Role in community

Agriculture and Livelihoods

2. **Can you tell me a bit about agriculture in the village?**
   - Crops grown - why?
   - Yields
   - Soils, landscape etc
   - Most important factors in affecting crop yields?
   - Rank them, same for all crops?
3. **What do you think are the key challenges for people living in this village?**
   - Differences/Similarities with other areas/Districts?
   - What do you think are the solutions to these challenges?
4. **Do you have anything else you want to add about the people/livelihoods/environment that hasn't been covered already?**

Past events and change

5. **Have you noticed any changes over last 50 years?**
   - Describe them
   - Positive / negative
   - Any changes in the environment? weather, soils, crops, water
   - Any changes in agricultural practices?
   - any before 1960s?
6. **Can you remember any particularly challenging or bad years for people in this area over the last 50 years?**
   - Any weather related events?
   - What kind of impacts did this have on agriculture / people? Short term / long term?
   - How did people cope or respond?
7. **Can you tell me about any recent or local challenges for farmers and agriculture in the last 5 years?**

   (use the first few interviews to identify the problems then make the subsequent interviews more targeted to explore those problems and the ways they were managed)

   - What immediate direct impacts has this had?
   - Did any changes take place as a result of challenge?
   - How are people coping with problems now?
   - Do you think ways of coping are the same as in the past?

8. **Can you tell me which years have been the best for agriculture in your memory? Why?** *(N.B Length of memory)* ⌈ Specific to a region, crop or a general /national problem? ⌈ Bad years? Why?
<u>**Weather and agriculture**</u>
9. **Can you tell me about weather over the last 50 years?** ⌈ Can you remember what itwas like before then (pre 1960)? ⌈ How has the weather affected people and agriculture? ⌈ Compared with weather now ⌈ Events people unable to cope with? Why?
10. **How does the weather affect agriculture and peoples' livelihoods** ⌈ In what ways?
11. **Have you noticed any changes in agriculture associated with changes in weather?** ⌈ Patterns ⌈ Main climate driver - Rainfall, temperature, etc ⌈ Wider environmental changes associated with weather
12. **Do you have any ways of predicting or knowing what the weather is going to be like?** ⌈ Source / Type of information – who can access it? ⌈ How much in advance? Time scale. ⌈ Local Indicators ⌈ How is the information used? ⌈ Useful? Why/why not? ⌈ Accuracy and Reliability
13. **Do you or people in the village have access to and use any climate / weather information from external sources?** ⌈ Source and Type of information? ⌈ Access to information ⌈ How much in advance? Time scale. ⌈ How is it used? ⌈ Useful? Why/why not? ⌈ Accuracy and Reliability
<u>**Policy**</u>
14. **What governmental or NGO agricultural programmes exist in this village?** ⌈ Effectiveness?
15. **What are your opinions on current agricultural policies?** ⌈ Effectiveness?
16. **What do you see as the current important agricultural policy issues in Uganda?** ⌈ Others
<u>**Uganda in 2030s**</u>
17. **What do you think will be the key challenges for people in this village over the next 20 years?** ⌈ Why? ⌈ Challenges for agriculture? ⌈ What policy interventions do you think are needed?
18. **What do you think agriculture in Uganda will be like in 20 years time (2030s)?** ⌈ Describe it ⌈ Why? ⌈ Key similarities / differences from now?

Other Discussion Topics

- **Climate change**

  What do you understand by the term climate change?

- **Vulnerability**

  Which sectors/geographical areas or people do you think are vulnerable to impacts of climate change? Why?

Appendix 4: Phase II Methods

Decision points used during semi-structured interviews with farmers to reflect the types of on-farm decisions made throughout the season.	
Stages	Key decisions
Preparations	When to prepare the garden? How much land to prepare?
Planting	What to plant? How much to plant? When to plant?
Agronomic management	Application of fertilisers and/or pesticides Weeding
Harvesting	When to harvest?
Post-harvest	What to do with harvest? How to store harvest? Where to sell harvest?

Semi-structured interview protocol for farmers (PhaseII)

Activity 1

Explain to farmers that this activity is designed to get them thinking about how they would respond to rainfall information. Imagine that I am an extension worker and each month I am going to come here and tell you how much rainfall we expect to fall in the coming month. I will tell you the total and we will draw it on the board. Then tell me what you would do in your garden in response to that rainfall information. I want to know when you 1) prepare the garden, 2) do 2nd tillage, 3) plant/sow, 4) weeding, 5) apply fertilisers, 6) apply pesticides, 7) harvest, 8) drying, 9)selling

Before we start with Round 1, Year 1:

- Ask how much land they own?
- How much did they cultivate last season?
- Pick top 2 crops that you planted this year in the first season, 2 that you planted last year 2nd season, top cash crop (if different from 1st/2nd season crops)
- Ask them why did they choose those crops to plant– (balance food security & cash)
- Explain that we will start with these 5 crops (write them in recording sheet for year 1)
- Ask where was the land they were grown on? (highland, lowland bush, swamp)
- Ask did they use any fertiliser / pesticide on them? Note this on recording sheet (if yes then ensure to prompt for this question)
- Now we are going to go through different rainfall scenarios for each month – once i have told you what the weather is expected to be like, then you have to tell me whether or not you would do anything in the garden. I am looking for when you 1) prepare the garden, 2) do 2nd tillage, 3) plant/sow, 4) weeding, 5) apply fertilisers, 6) apply pesticides, 7) harvest, 8) drying, 9)selling.

Now begin round 1:

- This year I only have information about how much rainfall we can expect in the coming month. Give the rainfall total for Year 1, January from Table 1. Ask research assistant to draw it on board. Ask if the farmer would you do anything in your garden? The same for all crops?
- Notes their responses on the recording sheet
- Go through month by month giving the rainfall totals and asking the farmer if they would do anything?
- Make sure that if a farmer says they normally use fertiliser/pesticide on that crop then you prompt for that question.
- When the respondent says plant for a specific or all crops in the first season, explain that for every acre of land they are given you 3 pieces of paper. They have to divide up the paper according to how they plan on planting. Note this down in the column % first season on the recording sheet. Repeat this process for 2nd season planting.
- When the respondent says harvest ask what they would do with harvest IN THAT SCENARIO. If they say drying / processing / selling then ask when and note this on recording sheet.
- At the end of each season, when respondent says harvest, ask the respondent given the weather and their experience, how would they rate their yield of each crop on a scale of 1-5? Explain the key / write it on board (1 very low yield, 2 low yield, 3 near normal/average yield, 4 high yield, 5 very high yield) Ask them to explain why they think this?

After this year has been completed begin round 2. Before we start with Round 2, Year 1:

- Explain that I am going to give you additional information about the year, then you must decide what crops you are going to plant and in what proportion of your land you would plant with each crop.
- Ask them why did they choose those crops & the proportions – (balance food security & cash)
- Explain that we will start with these 5 crops (write them in recording sheet for year 1)
- Ask where the land is that they would be grown on? (prompt if different to round 1)

Now begin round 2:

- Give the additional information for Year 2, Round 2 –
- Ask them to decide on 2 crops for 1st season, 2 for 2nd season & 1 other & why
- Ask how much of each crop will you plant in season 1 & 2 – use pieces of paper/land as before why?
- Note down selected crops & % of land
- Ask if they normally apply pesticides / fertiliser on this crop
- Notes their responses on the recording sheet
- Then deliver the additional information about the second season
- At the end of the season when respondent says "harvest", then ask the respondent given the rainfall & your experience how would they rate their yield of each crop on a scale of 1-5? (1 very low yield, 2 low yield, 3 near normal/average yield, 4 high yield, 5 very high yield) Ask them to explain why they think this?
- Repeat steps for Year 3, Round 2– making sure to give the annual information at the beginning of the year, then if possible correcting it at the second season to see if the new information makes a difference
- Refer to discussion points on recording sheet.

Repeat for remaining scenarios.

Semi-structured interview protocol for other policy actors

Topics for discussion

- Agriculture and Livelihoods
- Adaptation
- Climate change and policy
- Uganda in 2030s

1. **Can you tell me a little bit about yourself?**
- Place of birth, How long you've been in the district
- Role

2. **Can you tell me a little bit about the work that you do?**
- How long have you been in this position?
- Which ministries have you worked with in the last year?
- Which people have you worked with in the last year?
- Who are the stakeholders you work with? National/district/local levels?
- Which organisations have you worked with in the last year?
- Key Documents that influence your job - What important policy documents is your work influenced by?
- Key challenges you face in your job
- What did you do before this?

Agriculture and Livelihoods

3. **Can you tell me a bit about agriculture in the District?**
- Crops grown - why?
- Crop and Yields over time
- Soils, landscape etc
- Most important factors in affecting crop yields?

–Rank them - Same for all crops?

4. **What do you think are the key challenges for farmers in this District? / Uganda?**
   - Differences/Similarities with other areas/Districts?
   - What do you think are the solutions to these challenges?
5. **Do you have anything else you want to add about the people/livelihoods/environment that hasn't been covered already.**
6. **Have you noticed any changes in livelihoods since you have lived in this District?**
- Describe them (positive / negative)
- Any changes in the environment? weather, soils, crops, water
- Any changes in agricultural practices?

7. **Can you remember any particularly challenging years for farmers in This District over the last 50 years?**
- Any weather related events?
- What kind of impacts did this have on agriculture / people? (Immediately / after the event?
- What kind of changes happened as a result of the event?
- How did people cope or respond?

Semi-structured interview protocol for other policy actors

8. **Can you tell me about any recent or local challenges for farmers and agriculture in the past 5 years?**

(use the first few interviews to identify the problems then make the subsequent interviews more targeted to explore those problems and the ways they were managed)

- What immediate direct impacts has this had?
- Did any changes take place as a result of challenge?
- How are people coping with problems now?
- Do you think ways of coping are the same as in the past?

9. **Can you tell me which years have been the best for agriculture in this District in your memory? Why? (N.B length of memory – time in job)**

- Specific to a region, crop or a general /national issue?
- Bad years? Why?

<u>Climate change and policy</u>

10. **Which national policy documents influence your work?**

- In what ways do they influence your work?
- Key policy documents for agriculture?

- **What is your role in policy development / implementation?**
- What kind of information is currently used in this process? (linked to the steps in policy design/implementation)
- Do you think current policy processes are successful? Why / why not?
- Who is involved in policy design at a national / District level?

11. **What do you see as the current important policy issues this District?**

- Agricultural related ones
- Others

12. **What kind of agricultural programmes are you implementing on the ground?**

- What kind of activities are you implementing?
- Effectiveness?
- Any others to do with climate change? Environment?
- How effective do you think current government policy is? Government / your organisations programmes are?

13. **Does the weather affect your work? / the people you work with?**

- In what ways?

14. **Do you have access to and use any climate / weather information**

- Source and Type of information?
- How is it used?
- Useful? Why/why not?
- Accuracy and Reliability
- Do farmers have access to / use this? How?

<u>Uganda in 2030s</u>

15. **What do you think agriculture in this District will be like in 20 years time (2030s)?**

- Describe it
- Why?
- Key similarities / differences from now

Semi-structured interview protocol for other policy actors
16. **What do you think are the key challenges for agriculture over the next 20 years?** - Why? - What policy interventions do you think are needed?
17. **How do you think changes in the weather have affected crops? How would that affect farmers? How to prevent that from happening** - **Scenarios - Increases in temp, delayed rains, shorter seasons, unpredictability**
<u>Other Discussion Topics</u> - Give examples of climate services – have you seen them before? Used them before? - **Climate change** What do you understand by the term climate change? - **Politics of climate change** Do you think climate change is a political issue? Why/why not? - **Vulnerability** Which sectors/geographical areas or people do you think are vulnerable to impacts of climate change? Why?

Appendix 5: Phase III Methods

Questions for policy analysis

General

1. What are the policy objectives?

Agriculture

1. Does the policy mention agriculture? If so, what does it say?
2. What kind of information does it give about agriculture?
3. Does it mention any specific agricultural policies / activities? If so, what are they?
4. Does the policy discuss

   intensification/extensification/specialisation/diversification?

Climate Change

1. Does the policy mention climate change? If so, what does it say?
2. What kind of information does it give about climate change?
3. How does it describe climate change?
4. Does it mention any specific climate change policies / activities? If so, what are they?

Adaptation

1. Does the policy mention adaptation?
2. How does it describe adaptation?
3. Does it give any examples of adaptation, if so, what are they?

Appendix 6: Characterising Current Farming Systems

Characteristics of Jinja Farming System (JFS) and Soroti Farming System (SFS) compiled from a range of primary data sources, including focus group discussions (FGDs), semi-structured interviews (SSIs), household surveys (HHS) and observations (O).

Comparison between JFS and SFS	Jinja Farming System	Data Source	Soroti Farming System	Data Source
Climate and environment	Decline in natural forest cover	FGDs and SSIs	Grasslands with small shrubs and a few big trees	O
	Presence of a range of fruit trees, including mango, jack fruit, papaya	O and SSIs	Predominantly mango and orange trees	SSIs and FGDs
	Seasonal swamps in valleys	SSIs and FGDs	Seasonal swamps	SSIs and FGDs
	Two growing seasons (February/March–May and September–December)	SSIs and FGDs	Two growing seasons (March–June and July/August–November)	SSIs and FGDs
	Most land under cultivation—no communal grazing land	O and SSIs	Areas of uncultivated land and communal grazing land	O
	Combination of legal (freehold/leasehold) and customary land tenure system—women have no rights to customary land	SSIs and FGDs	Customary land tenure system—women have no rights to customary land	SSIs and FGDs
Crop production and agronomic practices	Rain-fed crop production	SSIs and FGDs	Rain-fed crop production	SSIs
	Main staple crops: maize, beans, sweet potatoes, groundnut, soya	SSIs and FGDs	Main staple crops: Cassava, sorghum, sweet potato, groundnut, peas	HHS
	Traditional seed varieties are diminishing	SSIs and FGDs	Integrated use of traditional and improved seeds	SSIs and FGDs

Characteristics of Jinja Farming System (JFS) and Soroti Farming System (SFS) compiled from a range of primary data sources, including focus group discussions (FGDs), semi-structured interviews (SSIs), household surveys (HHS) and observations (O).

Comparison between JFS and SFS	Jinja Farming System	Data Source	Soroti Farming System	Data Source
	Desire to use 'improved seeds' increasing	SSIs and FGDs	Mixed perceptions on use of 'improved seeds'	SSIs and FGDs
	Households sell crops from home, through middlemen	SSIs	Crops sold from local markets/trading centres	HHS, SSIs and FGDs
	Selling land/renting land out for sugarcane production	SSIs, FGDs and O	Oxen used for ploughing and tilling the land	SSIs and FGDs
	Use of hand hoes for tilling	SSIs and O	Low use of chemical fertilisers and pesticides	HHS, SSIs and FGDs
	Low use of chemical fertilisers and pesticides	SSIs and FGDs	–	–
Livestock and other agricultural activities	Small-scale agro-forestry, mostly fruit trees	O and SSIs	Some evidence of agro-forestry (e.g., orange trees and tamarind trees)	HHS and SSIs
	Small-scale livestock production—mainly poultry, goats and cattle	O and SSIs	Integrated crop and livestock production—mainly poultry, goats and cattle	SSIs and FGDs
	Role of livestock as safety net, income, food—predominantly financial asset	SSIs and FGDs	Varying cattle herd sizes	HHS
	High prevalence of tsetse flies and cattle diseases	FGDs	Role of livestock as safety net, income, food, and productive asset	SSIs and FGDs
	No evidence of apiculture	O and SSIs	Majority of households own poultry, goats and/or sheep	FGDs

Characteristics of Jinja Farming System (JFS) and Soroti Farming System (SFS) compiled from a range of primary data sources, including focus group discussions (FGDs), semi-structured interviews (SSIs), household surveys (HHS) and observations (O).

Comparison between JFS and SFS	Jinja Farming System	Data Source	Soroti Farming System	Data Source
	–	–	Role of oxen as productive resources	HHS
	–	–	Cattle as indicators of wealth	FGDs
	–	–	No evidence of apiculture	O and SSIs
Other natural resource based and off-farm livelihood activities	Evidence of other natural resource based activities on a small scale	O and FGDs	Evidence of a range of natural resource based activities	HHS and FGDs
	Emphasis on off-farm activities, for example small businesses and shops	O and FGDs	Some off-farm activities—e.g., casual work	HHS and FGDs
	Mostly men involved in off-farm activities (casual work)	FGDs	Men and women involved with off-farm activities	FGDs